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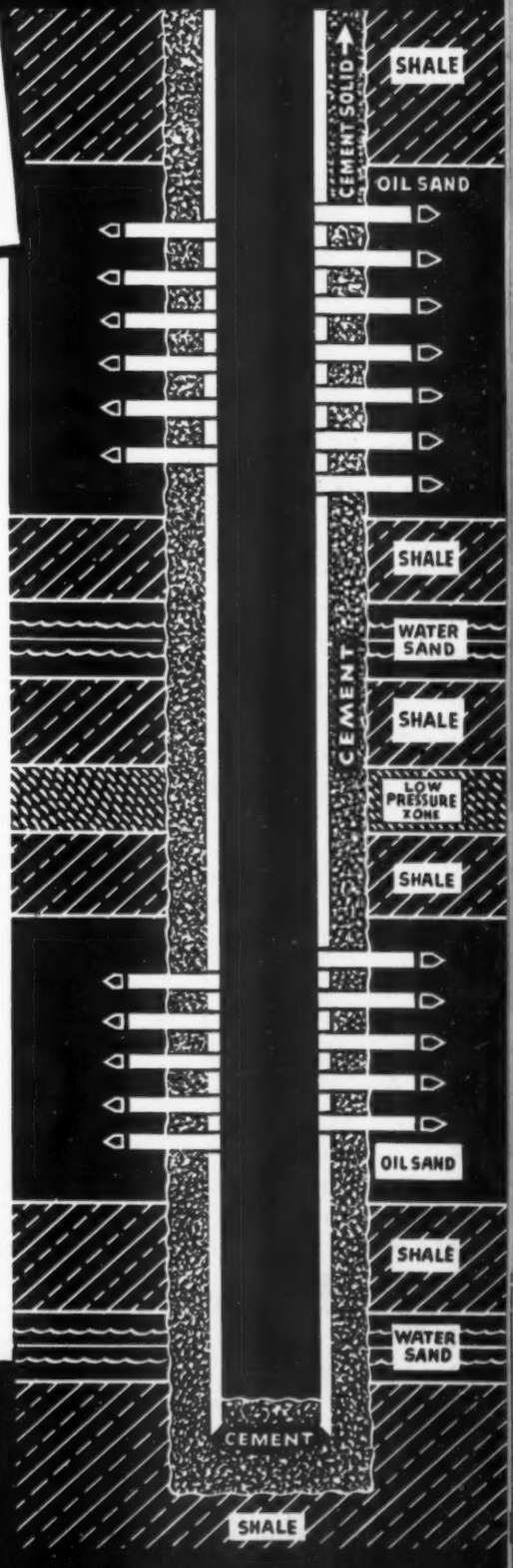

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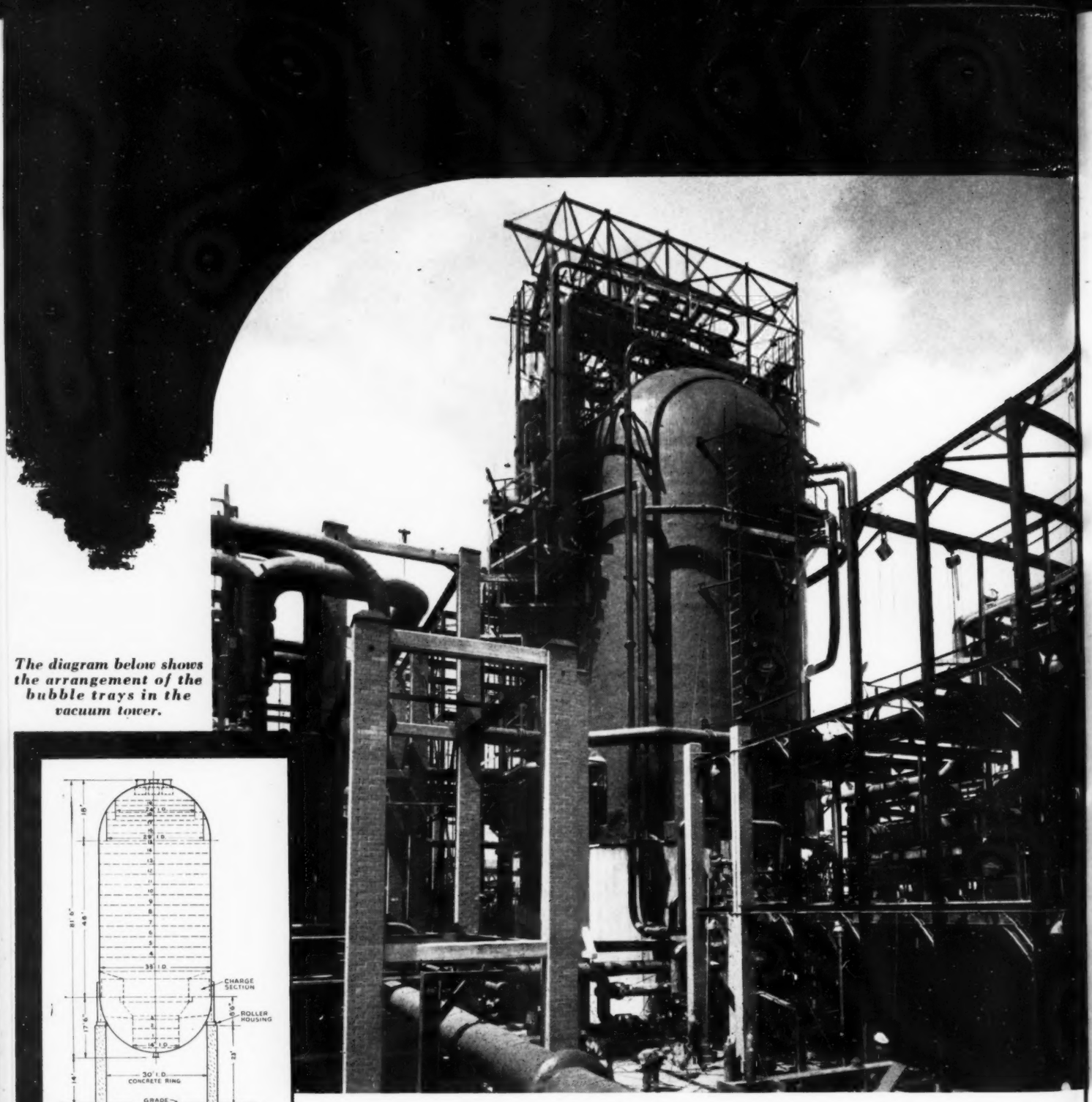
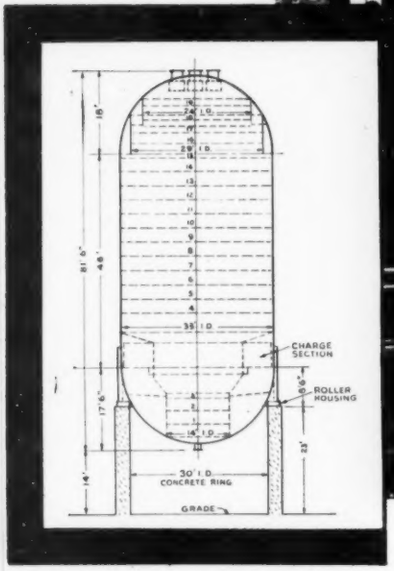


The diagram below shows the arrangement of the bubble trays in the vacuum tower.



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March, 1944

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MEMBER A.B.C.—A.B.P. (The articles in *The Petroleum Engineer* are indexed in the *Industrial Arts Index*, New York, N. Y.)

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Just a boy on a bicycle

The day is cold. Chill, too, is a youngster pedaling a bicycle around Richmond Refinery. He is collecting samples for constant quality tests at the laboratory. At one of his ports-of-call a man tosses over a pair of warm, wool-lined gloves. "Here, kid," he says, "you seem to need 'em."

Years flit. Some Standard Oilers are discussing the promotion won by a general favorite. One tells the story of the kid on the bike. He knows about it, for he was that shivering boy and the chap just promoted was the cold-weather friend who passed out the gloves. The one-time kid on the bike is happy over a grand break for a regular guy.

Of such people is this Company made up. We wish you could know them *all*. We wish you could think of our refineries less as pipes and stills and tanks, and more as Joe and Ed and Bill, who run them . . . of our wells as Red and Shorty, who get out the crude . . . of every tank-truck and service station in terms of the regular guys who man them.

As an army consists of men more than equipment, so Standard of California consists of people more than things. The men give an army its morale. Our people give Standard of California its character — its spirit. This Company is what its people are.

They are right people — man and boy and woman — honest, human, kindly people. Policy-makers at the top are yesterday's boys-on-bicycles . . . trucks . . . oil-rigs. All want to work for a company of which they can be proud. It follows as the night the day that Standard of California seeks to be a company its people can be proud to work for.

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The Course of Oil

by K. C. SCLATER

COMPACT MERITS CONSIDERATION

Confusion exists regarding the opposition of the petroleum industry to the proposed oil pipe line in Arabia. The necessity or otherwise of such a pipe line is not the immediate concern of the petroleum industry. The main point at issue and the one that is of immediate concern to the petroleum industry is whether the government should participate directly in any phase of foreign oil operations. This isssue involves government foreign oil policy, the provisions of which when formulated may have a profound effect on future foreign—and eventually domestic—oil operations. The industry sees in U. S. ownership of an oil pipe line in Arabia eventual government control and interference with development of foreign and domestic oil by private companies.

Justification for embarking on the foreign pipe line project is assertedly based on the fallacy that the imminent shortage of available domestic oil reserves will be permanent. Confident of its ability to continue to supply all civilian and war needs if given the opportunity to do so, the industry is unanimously opposed to direct government participation in foreign oil development. This explains the vigorous action being pursued by the Petroleum Industry War Council in advocating dissolution of the Petroleum Reserves Corporation.

It is up to the industry to aid in the formulation of a wise foreign oil policy. As a step in this direction it has drawn on its own experience in offering suggestions regarding what provisions should be incorporated in a foreign oil policy. In one of the most illuminating and constructive discussions that has appeared on this question, Joseph E. Pogue in an article "Must An Oil War Follow This War?" in the current issue of *The Atlantic Monthly*, points out that "when oil went to war, the government took the industry into collaboration. A dual system of planning and directives was developed in Washington, with the Petroleum Administration for War and the Petroleum Industry War Council working together as a team toward a common end. These new and effective administrative forms take rank, along with the other achievements of the American petroleum industry, as an outstanding contribution for future building. They may be commended to our lawmakers and administrators as an advance in the art of democratic government that deserves the widest attention. They offer the means of bringing the genius of oil enterprise in full measure and in acceptable form to the peoples of all nations."

In discussing a proposal for an international oil compact, Pogue goes on to state that, "It was this experience, and the belief that worldwide oil developments by our nationals would not only add to the security of the United States but would foster the social and economic advancement of all peoples, that prompted a group of oil leaders in November of last year to prepare and submit to our government a report on 'A Foreign Oil Policy for the United States.'

"This report outlined the factors that create an international oil problem, pointed out the special interests of the United States in oil, and listed the principles that should govern in framing a proper policy. It emphasized the effectiveness of private initiative, and the damaging results that would come from mixed operations with the participation of government. It stressed the necessity of dealing with both the interim and the long-term aspects of the problem, and differentiated between those measures which our government could take alone and those measures which, concerning the policies of other nations, required consultation and collaboration with others.

"Recognizing that a foreign oil policy requires not merely the formulation of principles but also the establishment of means for making these principles effective, the report offered two additional suggestions. One concerned special cooperation with Great Britain as the first step in achieving an agreement on general principles; the other proceeded on the idea that the forms of administration developed in the United States, in coordinating the oil interests of the Federal government, the oil-producing states, and the oil industry, could be adapted for effective application in the international field. To this end, the report concluded with a design for an International Oil Compact, in effect an Oil Conservation Treaty.

"The suggestion is offered that an International Oil Compact should be negotiated with the following general objectives: (a) efficient and orderly development of the world's oil resources; (b) prudent conservation of the world's oil reserves; (c) equitable distribution of oil to the peoples of all nations; and (d) avoidance of national restrictions imposed as artificial aids to the production of synthetic or substitute products. The Compact would be open to adherence by all countries, producing and consuming countries alike. It would become operative upon the adherence of five countries, provided the United States be one of the five; it is implicit, also, that Great Britain should be one of the five."

The proposed international contract would be constructed on an American model. "It would offer a means for coordinating the oil policies of various countries, precisely as we have succeeded in coordinating the policies of the American states. Without any invasion of national sovereignties, it would make possible progress toward an effective development of the world's oil reserves in an atmosphere of mutual understanding. It would bring together in common effort consuming and producing countries, local governments in special areas, and the competent men who must do the work if the world's oil needs are to be met."

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Highlights IN OILDOM

Turkey Rejects Oil Proposal

The Turkish government has rejected the application of an American oil combine for a concession to exploit oil resources in the Adana region. First news of the project was had when Ankara newspapers carried stories to the effect that such a concession was being sought, one-half of any production to go to Turkey and the other half to the exploiters.

The Turkish policy for years has been to avoid control of natural resources by foreign capital.

Navy May Develop Point Barrow Oil

The navy department disclosed recently that it is considering the possibility of developing its Point Barrow, Alaska, oil reserve and may begin exploratory work soon. A spokesman emphasized that the proposed development is still in the review stage and that no work is actually under way.

Illinois Spacing Rule Modified

Modification of federal spacing restrictions on Illinois oil wells March 15 likely will boost daily production 18,000 to 25,000 bbl., according to Director Robert M. Medill of the State Department of Mines and Minerals.

Under the new order four instead of two sand wells will be permitted on each 40 acres to the base of the Aux Vases sand strata regardless of depth, and two lime wells instead of one will be allowed on each quarter-quarter section to the base of the McClosky lime.

The order was agreed on, Medill said, after a conference attended by representatives of the State Oil and Gas Conservation Division and federal petroleum regulation officials in Washington, following negotiations with Petroleum Administrator for War Harold L. Ickes.

"This relaxation should result in hundreds of sand wells being drilled or deepened to the Aux Vases below 2500 ft. and many lime wells deepened or drilled to the McClosky lime," Medill said.

"It should result in a large increase of daily production as most tests will be on proved locations," he stated.

S. F. Peterson, oil and gas division petroleum engineer, estimated 755 wells can be drilled or deepened to the Aux Vases base.

Want Price Increase; Oppose Subsidy

Directors of the Independent Petroleum Association of America and the National Stripper Well Association went on record at a meeting in St. Louis recently as favoring a 50 cents a barrel increase in crude oil prices. A joint statement said: "While a year or more ago 35 cents per bbl. might have been sufficient, because of increased expenses and costs since that time, it will take not less than 50 cents per barrel increase."

President Roosevelt was petitioned to "order his subordinate administrative officers in charge of price control to so adjust the price ceilings on crude oil and its products as to permit the functioning of an industry in the service of our country in the manner in which it is best fitted to the end that it may provide the products so necessary to the safety and welfare of this nation."

A resolution directing that such a petition be forwarded to the president was adopted at a special meeting of more than 100 directors of the associations. The action was a culmination of the four days' deliberation of the directors on invitation of the Office of Price Administration to make suggestions on OPA's proposal to increase ceiling prices for crude oil and to provide a subsidy for production from stripper wells.

A second resolution was adopted renewing opposition to government entry into the oil industry in general and the Arabian pipe line project in particular. The group recommended that Congress take action to nullify the pipe line project, to dissolve the Petroleum Reserves Corporation, and to prohibit the participation of government as a proprietor in the operation, development, or management of any petroleum company or companies, in foreign or domestic activities, and to make provisions against any other commitments by government to encroach upon a free industry, abroad or at home.

The petition to the President is the answer of independent oil men on the question of subsidies for the oil industry. They oppose subsidies. OPA said it had been ordered to prepare a subsidy plan for increasing oil prices. IPAA and NSWA were asked to aid in preparing such a plan. Being irrevocably opposed to such a plan, the two organizations felt it incumbent upon them to present their views, spokesmen said, which resulted in the meeting with the outcome as outlined.

Oil Parley Slated

An Anglo-American conference on world oil problems is scheduled for Washington soon, it was announced recently by acting Secretary of State Edward R. Stettinius.

Secretary of State Hull is to head the committee of six Americans named to conduct the petroleum talks for this country. Petroleum Administrator Ickes is vice-chairman of the delegation.

Although Stettinius said all petroleum questions of mutual interest to the United States and Great Britain could be brought up at the talks, it is expected that the fields of the Near East, where both British and American firms have concessions, will form the major topic.

Compact Meeting April 3-4

"Oil for Tomorrow," the Interstate Oil Compact Commission's educational film, will have its grand premiere before an audience of industry leaders and public officials at the compact's spring quarterly meeting April 3 and 4, in the Roosevelt Hotel, New Orleans, Louisiana. Scheduled as a part of the first day's public session of the commission, the 30-minute movie, in sound and color, will tell the story of progress in oil and gas conservation.

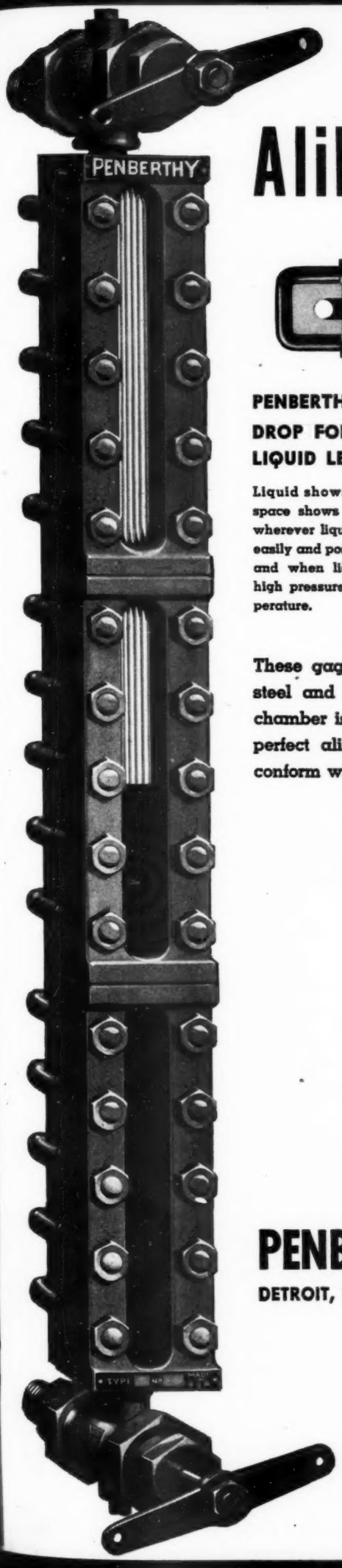
Gas cycling operations, a source of high octane fighting gasoline and an important industry in Louisiana, will be the theme of a paper by R. L. Keyes of New Orleans, assistant division manager of The Texas Company.

Sharing equal interest on the two-day program will be the discussion of Louisiana's modern oil and gas conservation law by George A. Wilson, former general counsel for the Department of Conservation, now Director of PAW's Transportation Division, Washington, D. C.

The administration of the law will be demonstrated by an official public hearing to be conducted by Conservation Commissioner Joseph L. McHugh.

Problems destined to confront the states in the period following the cessation of the present world conflict, will be described before the commission by Frank Bane of Chicago, executive director of The Council of State Governments.

Compact committees will be in session and will present formal reports at the closing session.



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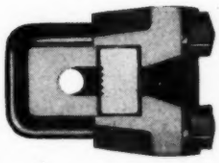

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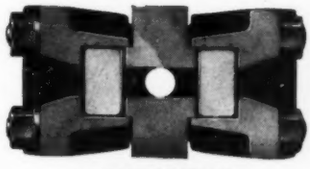

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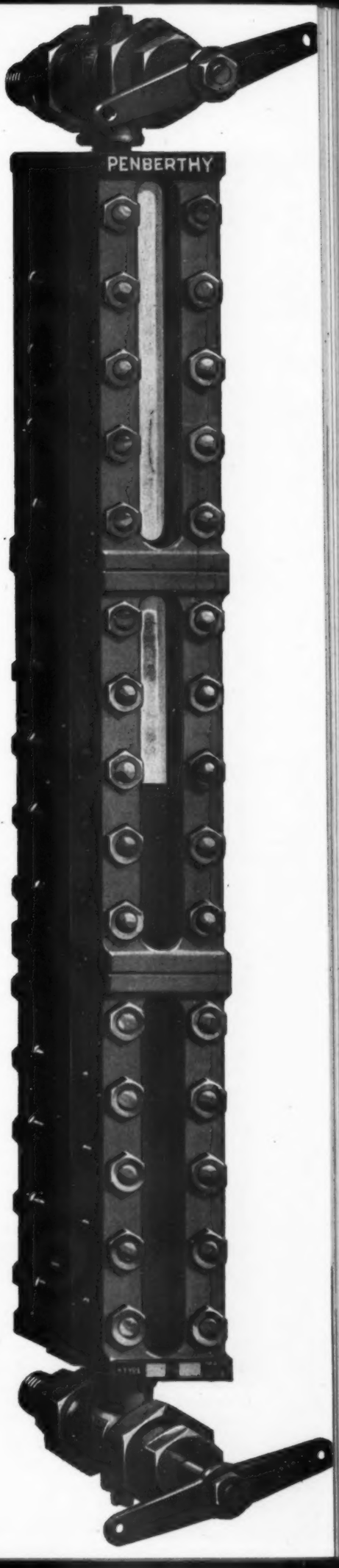

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PENBERTHY PRODUCTS

MAJOR *Pipe Line* ACTIVITIES

REPORT of the negotiations in progress whereby Petroleum Reserves Corporation would finance a pipe line across Arabia brought an avalanche of criticism from the oil industry and members of Congress. The most comprehensive protest came from the Petroleum Industry War Council, which issued a document stating that the project "is a signpost of the new highway of international power politics not yet revealed to and approved by the senate of the United States."

The council said the plan to run the 1200-mile line through three foreign nations between the Persian Gulf and the eastern end of the Mediterranean was an invitation to international incidents rife with germs of another war and constituted the Fascist approach—the corporative state, with its lust for imperialism—the shackling of free American enterprise, not to better serve, but to displace private enterprise, at not only the risk but with certainty of international involvement.

Seventy-five miles of 10-in. pipe line will be added to the Gulf Oil Corporation system from West Texas to Weatherford. Contract for laying the five loops has been awarded Sharman and Allen of Houston, Texas. The loops will lengthen the Gulf pipe line system and will increase the capacity from 70,000 to 80,000 bbl. daily. Some of the increased capacity will be moved from Weatherford over an 8-in. system to Saltillo, from whence it will be moved to Big Sandy.

At Big Sandy an 8-in. line will be laid to Longview to tie into the Big Inch line. This will permit delivery of 16,000 bbl. a day of West Texas crude into the Big Inch. One loop will be laid 17 miles from Judkins to Midland, with a 9-in. loop on the discharge side of the latter station. Loops will straddle the Coahoma and Roscoe stations, increasing the capacity to a maximum of 90,000 bbl. daily to Sweetwater. This line serves the Gulf refinery at Sweetwater. From Saltillo south to Big Sandy, a 13½-mile loop will be laid, with 27½ miles of 8-in. to be constructed to Longview.

Test runs have probably already been made in the American-financed Canol project pipe line from Norman Wells, Northwest Territory, to Whitehorse. Final links were welded last month near Macmillan Pass astride the Arctic Continental Divide in the Mackenzie Mountain range. Completion of the pipe line marked a vital point in the $130,000,000 project undertaken by the United States Army after a Japanese attack on Alaska appeared possible. Work began in June, 1942, on the project, which included development of production at Norman Wells, building a refinery at Whitehorse, and the 4½-in. pipe line from production, near the Arctic Circle, to the refinery. Crude oil from the 30 or more wells at Norman Wells is said to be moving now in the 600-mile pipe line. The line is said to be capable of moving 3000 bbl. a day.

A pipe line is reported to be planned in Mexico to connect Tampico to a new refinery to be constructed in Guadalajara. The government newspaper El Nacional made the announcement but gave no date for the beginning of the project. Officials connected with the government oil industry denied any knowledge of plans to lay pipe lines across the Isthmus of Tehuantepec.

The Federal Power Commission has received applications for new construction to increase the capacity of the pipe line carrying gas from the Hugoton field, Oklahoma, eastward to consumers of the Cities Service Gas Company, Bartlesville, Oklahoma. The company serves Kansas City, Topeka, and other communities in Kansas, Missouri, Southern Nebraska, and Northern Oklahoma. Applications filed by that firm and the Cities Service Transportation and Chemical Company state that the new facilities would assure continued and adequate service to essential war plants in 1945.

As originally approved last September, and recently completed, the line has an initial capacity of 140,000,000 cu. ft., and by installing additional compressor stations it is proposed to attain a delivery capacity of 220,000,000 cu. ft. in 1945, and 240,000,000 cu. ft. in 1946. The new applications ask to raise the capacity of the line to 213,000,000 cu. ft. by October 15, 1944.

Items in the construction applied for include: (1) seven 1000-hp. gas compressor units and related facilities to be installed by the transportation and chemical company in its Guymon, Oklahoma, station at an estimated cost of $1,298,-354 and, when completed, to be operated by the gas company under a proposed lease between the two firms; (2) a cooling tower to be constructed by the gas company at its station in Blackwell, Oklahoma, the eastern end of the Hugoton pipe line; (3) 35 miles of 16-in. loop line to be built by the gas company from Blackwell to Osage County.

The Federal Power Commission has set a hearing for March 24 in Washington on two applications filed by the Panhandle Eastern Pipe Line Company of Kansas City, Missouri, for permission to build and operate two short natural gas pipe lines in Michigan.

Facilities for the transportation of petroleum products in Mexico showed considerable improvement between 1938 and 1943, the United States Department of Commerce has been advised. Capacity of 3 pipe lines was increased from 75,000 to 210,000 bbl. daily, and a further increase is said to be under consideration.

Mexico's tank cars in use in 1943 totaled 1410, whereas there were only 771 in 1938. Oil trucks increased from 458 in 1938 to 530 last year. Rated storage capacity rose from 1,397,169 bbl. to 1,725,786 bbl.

The $8,000,000 war emergency Bayou Pipe Line System, which extends from Texas refineries to Baton Rouge, Louisiana, will in the future be administered as a division of the Texas-Gulf area of the Shell Pipe Line Company, according to H. H. Anderson, vice president. It will be under the supervision of C. D. Winkelman, who was promoted from superintendent of the Bayou system to superintendent of the Texas-Gulf area with headquarters in Houston, Texas. S. B. Bean has been appointed superintendent of the Bayou division with headquarters at Port Neches.

Winkelman succeeded L. F. Young, who was transferred to Cushing, Oklahoma, as superintendent of the Mid-Continent area last January. C. P. Wilson, who has been Baytown terminal supervisor of the Bayou system, has been named foreman of the Baytown district. W. H. Craddock, former superintendent of the Louisiana division, has become division superintendent of Shell's Mid-Continent area with headquarters at Healdton, Oklahoma.

The Bayou Pipe Line is jointly owned by the Humble, Texas, Shell, Pan-American, Pure, and Crown Central pipe line companies. It was designed and constructed by Shell Pipe Line Corporation and will be operated by it for the duration. The Bayou system was designed to deliver an average of 57,000 bbl. a day but its operators have managed to average 63,500 bbl. daily. The line replaces tankers and barges in feeding the Baton Rouge terminals of the Plantation pipe line, which is laid to Richmond, Virginia.

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MAJOR *Oil Field* ACTIVITIES

▶ **Alabama.** Said to be the first oil discovery in the state, Hunt Oil Company No. 1 Jackson is making 50 to 60 bbl. of 20 gravity oil a day from the Selma chalk at 2800 ft. Location is 15 miles east of production in Mississippi, in SW NE 2-10n-4w. Drilled to 5380 ft., the well was plugged back to make the test.

▶ **Texas.** Eastern Cass County reported the discovery of a new gas field from the Hill zone, top sand in the Rodessa series, which was found at 5850 ft. Skelly Oil Company No. 1 Baldwin, James Taylor survey, flowed 3,000,000 cu. ft. gas.

▶ **Kentucky.** A new producing horizon for the East Poole pool of Webster County has been discovered at Sinclair Wyoming Oil Company No. 1 Lillian Ashby, 10-N-23. The well had good Tar Springs sand production at 1798 to 1811 ft., pumping 205 bbl. of oil in 24 hr. It is the second well drilled in the new area. The first one produced from both McClosky lime and Cypress sand.

▶ **Texas.** Shell Oil Company established a deeper producing horizon in the Manziel Paluxy sand pool in northern Wood County. No. 1 Whatley, Polk survey, gauged 169 bbl. in 20 hr. Production is said to come from the Travis Peak of the basal Trinity.

▶ **New Mexico.** Danciger Oil and Refineries, Inc., No. 1 Friess, 30-17s-31e, has been completed for daily production of 47 bbl., flowing after shooting the pay at 2057 ft.

▶ **Kansas.** Cities Service Oil Company No. 1 Sikes, discovery well in SW SW SE 27-9-19w, Rooks County, has been given a productivity rating of 1326 bbl. of oil daily from the Arbuckle, at 3623-67 ft.

▶ **Kansas.** The H. B. Mabee et al No. 1 Eubank, NEC 4-27-14w, Pratt County, looks like a new pool opener. It topped the Lansing-Kansas City lime at 3940 ft.

▶ **Kentucky.** A new McClosky lime pool for Union County appeared certain after preliminary tests at The Texas Company No. 1 Culver, 12-P-20, 2½ miles northeast of the Uniontown pool. Production is from 2521-31 ft.

▶ **Oklahoma.** A rich Dutcher sand pool appears to be opened by Dale Sneed and Robert E. Garrett at No. 1 Eaton, SW NW SE 12-14-10e, Creek County. The Dutcher was encountered at 2522-40 ft. After swabbing it flowed 60 bbl. in 70 min.

▶ **Texas.** Stantex No. 1-109 State-Galveston Bay has opened a new pool in Galveston Bay off Smith Point, Chambers County. The well made 13 bbl. an hr. through 5/32-in. choke from perforations at 8135-46 ft.

▶ **Louisiana.** A new producing level in the new Kingston Holly field was established by the Texas Mineral Land Company of Dallas No. 4 E. P. Lee, township 14 north, range 13 west, De Soto Parish. Production of 92 bbl. an hr. comes from 2700-74 ft., only a few feet deeper than the upper pay sand.

▶ **Illinois.** Gulf Refining Company No. 1 Parsons, a pool opener in SWC 7-4s-14w, near Crossville, swabbed 68 bbl. of oil and 9 of water in 24 hr. from Paint Creek sand. Total depth of the hole is 2826 ft.

▶ **Oklahoma.** The Ashland Oil and Refining Company of Ashland, Kentucky, appears to be opening a new pool in Seminole County. Its No. 1 Key, CNL NW SE 17-8n-8e, topped the Misener sand at 3918 ft. and a drillstem test produced oil and gas cut mud, no water.

▶ **Kansas.** Latest production test of Mineral Products Company No. 1 Reif, discovery well NWC SW 30-16-12w, Barton County, credits the well with making 13 bbl. an hr. on the swab from Arbuckle.

▶ **Texas.** Discovery of a new sand in the west Ganado field of Jackson County was made by Pure Oil Company in its No. 1 Delia Wise, which was completed for 104 bbl. of oil a day from a total depth of 6360 ft.

▶ **Kansas.** Stafford County appears to have a new pool opener in No. 1 Neill, NWC NE 27-24-11w. The well, operated by Atlantic Refining Company, made 221 bbl. a day from Arbuckle lime at 4240 ft.

▶ **Illinois.** The Texas Company apparently has opened a new pool at No. 1 Green, CS½ SE SE 15-1s-3e, Jefferson County. After acid treatment some oil was swabbed from the McClosky lime. Shows of oil were found in Aux Vases sand.

AVERAGE CRUDE OIL PRICES

California		Louisiana	
Kettleman Hills	$1.23-1.29	Rodessa	$ .88-1.20
Playa Del Rey	.80- .87	Gulf Coast	.93-1.36
Coalinga	.73-1.13	North Louisiana	.98-1.30
Wilmington	.68-1.24		
Montana	1.00-1.15	Illinois	1.22-1.37
Wyoming	.45-1.15	Kentucky	1.32-1.43
Colorado	1.05-1.07		
New Mexico	.70-1.15	Indiana	.85-1.25
Texas		Ohio	
North Central	.97-1.25	Lima	1.50-1.60
Panhandle	.70-1.12		
West Texas	.80-1.27	Michigan	1.24-1.44
Gulf Coast	.93-1.48		
Darst Creek	1.14	Pennsylvania	
East Texas	.80-1.27	Bradford	3.00
Talco	.79	Southwest	2.65
Kansas	.93-1.25	Eureka	2.59
Oklahoma	.75-1.25	Buckeye	2.30
Arkansas	.94-1.36	Corning	1.31

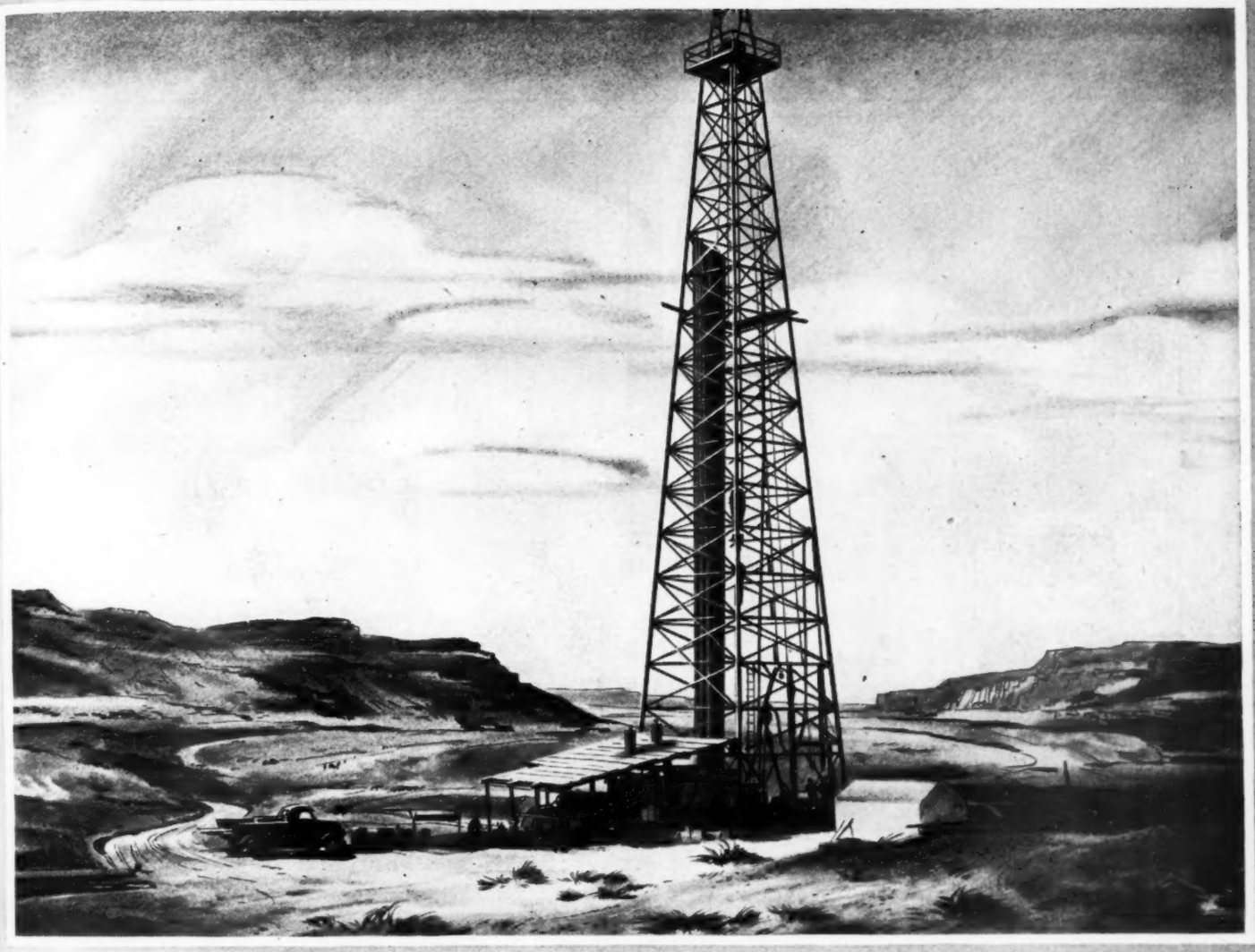
DAILY AVERAGE CRUDE OIL PRODUCTION

Data Supplied by A.P.I.

(Figures in bbl. of 42 gal. each)

	*P.A.W. Recommendations February	ACTUAL PRODUCTION Week ended Feb. 26 1944	Week ended Jan. 29, 1944	Week ended Feb. 27, 1943
Oklahoma	328,000	325,400	328,800	347,700
Kansas	285,000	268,050	286,700	316,650
Nebraska	1,200	1,100	1,150	2,600
Panhandle Texas	.....	102,000	97,900	88,900
North Texas	.....	139,950	140,200	135,350
West Texas	.....	362,000	364,600	213,900
East Central Texas	.....	100,250	116,400	100,000
East Texas	.....	390,600	366,200	325,100
Southwest Texas	.....	362,000	364,600	213,900
Coastal Texas	.....	516,600	520,800	322,100
TOTAL TEXAS	1,886,000	1,909,650	1,899,650	1,343,100
North Louisiana	.....	77,200	76,850	90,750
Coastal Louisiana	.....	283,100	280,900	246,550
TOTAL LA.	348,700	360,300	357,750	337,300
Arkansas	76,600	78,750	78,300	75,250
Mississippi	46,000	42,600	44,400	55,000
Illinois	215,000	211,100	217,200	242,700
Indiana	14,000	12,450	14,000	15,800
Eastern	72,200	68,700	73,600	63,100
Kentucky	25,200	20,100	22,500	19,650
Michigan	50,000	53,500	52,900	58,600
Wyoming	93,000	95,400	97,050	91,700
Montana	23,700	20,950	20,950	21,450
Colorado	7,000	6,900	6,300	7,100
New Mexico	110,700	112,850	113,000	96,600
TOTAL EAST OF CALIF.	3,582,300	3,587,800	3,614,250	3,094,300
California	836,500	796,700	795,200	780,000
TOTAL U. S.	4,418,800	4,384,500	4,409,450	3,874,300

*P.A.W. recommendations and state allowables, as shown above, represent the production of crude oil only, and do not include amounts of condensate and natural gas derivatives to be produced.



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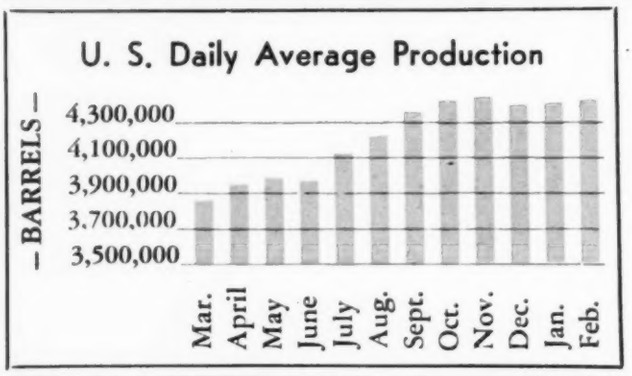
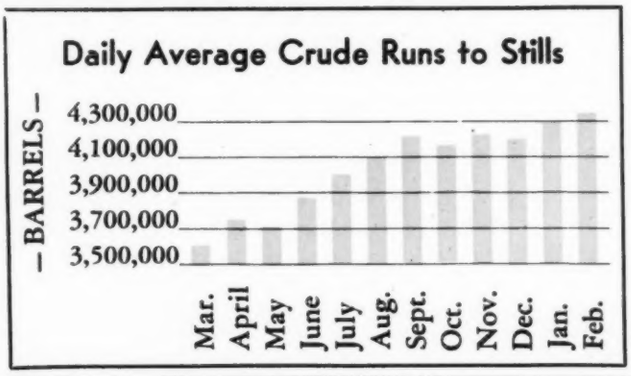
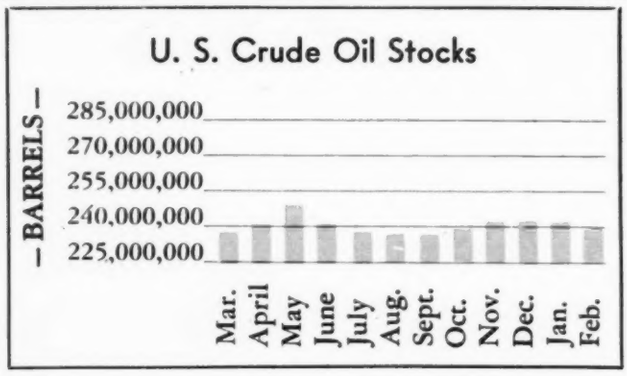
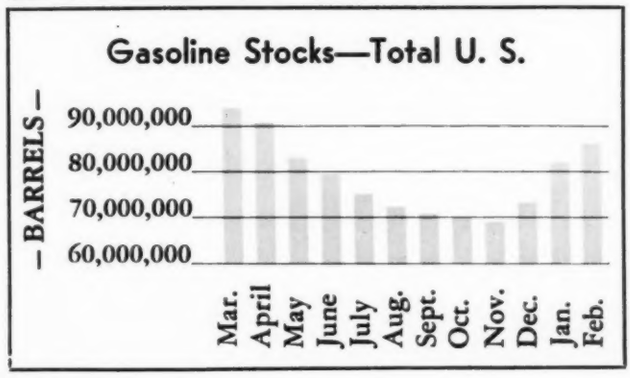
PETROLEUM *Statistics* AND FIELD *Operations*









Above statistics by American Petroleum Institute.

Summarized Operations in Active Fields for February, 1944

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
Eastern Texas	20	14	13	....	3500-3700	2	40	Rotary
Gaines County	30	21	3	....	4400-5584	2	22-35	Rotary
Hockley County	16	11	8	....	4800-6850	2	20-30	Rotary
Ector County	14	10	8	....	3675-4377	2 or 3	32-36	Rotary
Panhandle	18	14	7	....	1700-3900	2	40	Rot.-Cab.
Nueces County	13	10	8	....	3922-5878	2 or 3	21-54	Rotary
K. M. A. Field	12	11	5	....	3730-3935	2	42-43	Rot.-Cab.
Hawkins Field	6	4	7	....	4495-4912	2	19-29	Rotary
OKLAHOMA								
Okfuskee County	9	6	7	....	2150-4125	2 or 3	38	Rotary
KANSAS								
Russell County	12	10	5	....	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	7	3	4	....	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	8	6	5	....	3290-3518	2	39-42	Rot.-Cab.
ILLINOIS								
Central Illinois	150	128	95	90	1425-4100	2	36-38	Rot.-Cab.
NEW MEXICO								
Lea County	7	5	3	....	3150-4030	2	30-34	Rot.-Cab.
CALIFORNIA								
Kern County	7	7	7	4	1840-11,450	2 or 4	14-30	Rotary
Wilmington County	7	7	10	13	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for February, 1944

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1943 (bbl.)
	February	January	February	January	February	January	February	January	February	January	
Arkansas	18	13	9	9	16	11	7	7	13	....	27,605,000
California	71	144	64	116	60	58	30	26	21	16	284,415,000
Illinois	138	156	126	121	81	79	90	80	103	112	81,070,000
Indiana	40	26	31	24	26	31	6	5	14	16	5,320,000
Kansas	180	180	132	142	50	52	23	27	14	25	105,780,000
Kentucky	51	40	30	31	15	19	....	....	....	....	7,890,000
Louisiana	49	42	34	40	24	18	10	....	16	....	125,904,000
Michigan	51	56	41	43	20	31	11	....	13	20	20,576,000
Mississippi	5	4	3	3	....	....	....	....	....	....	18,845,000
Montana	16	25	7	19	....	....	5	7	....	....	7,598,000
Nebraska	....	7	....	5	3	....	....	....	....	....	791,000
New Mexico	21	33	15	25	11	9	....	....	....	....	38,955,000
New York	105*	98*	101*	95*	49	56	24	15	....	....	4,783,000
Ohio	60	50	49	48	30	28	19	14	....	....	3,220,000
Oklahoma	121	130	93	119	44	41	....	....	46	43	120,880,000
Pennsylvania	200*	218*	170	191	149	161	....	....	....	....	15,986,000
Texas	335	380	274	321	294	311	240	220	290	291	588,560,000
West Virginia	61	78	51	72	22	12	3	3	15	14	3,256,000
Wyoming	8	11	5	8	4	1	3	1	13	5	34,686,000
Total	1530	1691	1235	1452	898	918	471	405	558	542	1,496,120,000

*Includes water-intake and pressure wells.

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MAJOR *Refining* ACTIVITIES

WORD has been received that an American firm will take over the management of a refinery at Mexico City after it has been rebuilt to produce 100-octane gasoline, a fuel badly needed by United States airplanes that travel to Mexico. At present this motor fuel is being shipped to Mexico from the United States because the refineries there cannot make it.

Negotiations between the Petroleum Administration for War and important oil officials of the Mexican government have been in progress although details of the decisions made have not been revealed. Members of the Export-Import Bank have been called in, it is said, to work out financing of the project with lend-lease funds. Materials will be given priority by PAW and construction work will be done by the Arthur G. McKee Company.

It has been reported that Phillips Petroleum Company is the American firm that will manage the operation. Part of the project will be the repressuring of the Poza Rica field. It is thought that the conversion of the Mexican plant to the production of 100-octane gasoline will not come under the supervision of Petroleum Reserves Corporation but will be done through the state department.

"Clarkson, Ontario, has a new and well equipped refinery recently put into operation, according to the Dominion press. Crude oil for the plant will be transported by tanker across Lake Ontario and a 1900-ft. dock owned by the plant will provide space for berthing five tankers simultaneously. Direct connection with transcontinental rail lines and proximity to highways permit Dominion-wide distribution of products.

After plans to build the plant for the production of lubricating oil had been made they were expanded to include production of aviation gasoline. The equipment also provides for output of a variety of products ranging from methane to a heavy grade of asphalt. The plant is said to have a polyforming process that utilizes the best features of cracking, reforming, and gas reversion that have been evolved in other plants over a number of years of experimentation. The entire unit is a compact system and provides for reforming any of the charging stock in a manner to produce desired end products in virtually any proportion desired.

The Clarkson plant has a carefully coordinated system of electric and pneumatic controls, which record in the control room an overall picture of temperatures, pressures, and flow-rates of the oil and its products in all units of the plant. With a tankage capacity of 1,771,414 bbl., the plant can handle 10,000 bbl. of crude oil each 24-hr. day and can produce 1000 bbl. of lubricating oil.

The world's largest plant for the production of butadiene from petroleum was dedicated at Port Neches, Texas, in February with a ceremony witnessed by more than 4000 representatives of the petroleum and rubber industries and high government officials. Estimated overall cost of the plant is $100,000,000. For 18 months 8000 workers constructed the huge unit in what had been a swamp. In a few months butadiene rubber at the rate of 50,000 tons a year will be produced at the vast plant and ultimate production is estimated at 100,000 tons of rubber a year.

Consumers Cooperative Association has voted to purchase a $2,000,000 refinery to serve farmer cooperatives in Texas, Oklahoma, New Mexico, and Colorado. Delegates from 65 local cooperatives in the four states pledged $128,000 toward the purchase price at a meeting in Amarillo, Texas. Officials said that, if purchased, the refinery would be the first one owned cooperatively in Texas. There are nine refineries owned by cooperatives in the west and middle west.

Howard A. Cowden, North Kansas City, Missouri, is president of the Consumers Cooperative Association, which owns three refineries and has an interest in a fourth. It was reported that total sales of $2,134,206 were registered by the CCA in Texas last year.

The Western Petroleum Refiners Association will hold its thirty-second annual meeting March 28 in St. Louis, Missouri, at the Jefferson Hotel, it was announced by J. C. Day, secretary. The meeting will be in the form of extemporaneous discussions and round table conferences. Crude for midwestern refiners will be discussed by W. W. Vandever, director of PAW for District 2. Paul G. Ryan will speak on petroleum in the postwar period, and Bruce K. Brown, assistant deputy administrator of PAW, will talk on wartime petroleum refining.

In the United States the House passed a bill authorizing the Bureau of Mines to build experimental plants for producing motor and aviation gasoline from coal, oil shale, agricultural and forestry products. The program's cost was set at $30,000,000. Secretary of the Interior Ickes has warned Congress that domestic petroleum reserves will last about 14 years. The Bureau of Mines said there are enough coal reserves to supply synthetic fuel for 3000 years.

The islands of Curacao and Aruba, in the Caribbean Sea, have increased their refinery capacity to 600,000 bbl. a day, according to the foreign press. Before the war, when refining capacity was about 500,000 bbl. a day, the Dutch colony exported petroleum products valued at from 40 to 50 million pounds sterling annually, or around 200 million dollars.

Crude Runs to Stills, Production[1] and Stocks[2] of Motor Fuels

A.P.I. Figures

(Figures in thousands of bbl. 42 gal. each)

DISTRICT	DAILY REFINING CAPACITY Potential rate	DAILY REFINING CAPACITY Per cent reporting	CRUDE RUNS TO STILLS Daily average	CRUDE RUNS TO STILLS Per cent operated	Total production[3]	Total stocks[3]
*Combined: East Coast, Texas Gulf, Louisiana Gulf, North Louisiana-Arkansas, and Inland Texas	2,448	90.0	2,138	87.3	14,197	71,631
Appalachian						
District No. 1	130	83.9	100	76.9	521	3,222
District No. 2	47	87.2	50	106.4	306	1,883
Ind., Ill., Ky.	824	85.2	768	93.2	4,694	28,987
Okla., Kans., Mo.	416	80.1	348	83.7	2,184	11,329
Rocky Mt.						
District No. 3	8	26.9	12	150.0	77	133
District No. 4	141	58.3	92	65.2	647	2,943
California	817	89.9	832	101.8	5,484	57,717
TOTAL U. S.— February 19, 1944	4,831	87.1	4,340	89.8	28,110	177,845
TOTAL U. S.— February 12, 1944	4,831	87.1	4,228	87.5	27,687	177,174
U. S. February 20, 1943	.....	.....	3,668	.....	23,276	204,669

*At the request of the Petroleum Administration for War.

[1]Production—total of gasoline at refineries including natural and blended; kerosine, gas, and distillate fuel oil, and residual fuel oil.

[2]Stocks at refineries, bulk terminals, in transit, and pipe lines of finished and unfinished gasoline; kerosine, gas, oil, and distillate fuel, and residual fuel oil.

[3]Figures on production and stock include reported totals plus an estimate of unreported amounts and are on a Bureau of Mines basis.

THE Petroleum Engineer

MARCH, 1944

Problems of High Pressure Drilling in India

☆ Advancements in equipment design and operating technique solve difficulties in Khaur field

by
Wallace A. Sawdon
Pacific Coast and Foreign Editor

PRODUCTION from the Khaur field in Punjab Province of India comes from both shallow and deep zones. Although some oil is being taken from small, old wells at very shallow depths, most of the production is from zones up to 3800 ft. in depth and from a deeper sand found at approximately 5600 ft. The extremely high pressure of a water sand at approximately 5000 ft. makes the drilling of the deeper wells somewhat difficult. Much trouble was experienced in getting through this sand while drilling the earlier of the deep zone wells, but methods and equipment have since been developed to insure successful passage through the high pressure zone.

In drilling the deep wells in the Khaur field it has been the practice to cement a 11¾-in. surface string; then drill with 80 to 85 lb. per cu. ft. mud until the depth approached that at which the high pressure water sand was known to lie. The mud was made from shale that outcrops near the field and this shale was capable of making a readily pumpable fluid weighing more than 90 lb. per cu. ft.

A string of 8⅝-in. casing was set above the high pressure water zone and was cemented from the shoe to the surface. It was set both to shut off formations above this zone that might take fluid and cause trouble and to reduce open hole above the zone to a

Hydraulic ram with adjustable weight below the derrick floor

minimum. High pressure surface connections were made up on the 8⅝-in. casing, as shown in the sketch of a typical hook-up given in Fig. 1, and drilling was resumed with 7⅞-in. hole. In drilling the high pressure wells the size of the hole was only ⅝ in. larger than the outside diameter of the next string of casing to be set. This was not underreamed and flush joint casing was used.

Pressure High

The high pressure sand made a tremendous volume of water during the drilling of the first wells, but this volume was depleted as more holes were drilled. The pressure, however, built up rapidly when the sand was penetrated so the driller watched the hole carefully as he approached the top of the zone to observe whether the fluid increased. When the sand was reached the circulating system was closed in and drilling from that point continued under pressure until the high pressure sand was drilled through and the water string was run and cemented.

While going through this zone drilling was done either with back pressure being held on the mud returns by means of flow beans or with the circulating system completely closed and the mud fluid returned directly to the suction end of one of the pumps. Conditions governed which method was to be used and connections were so arranged that the driller could switch from one method to the other whenever he thought it desirable.

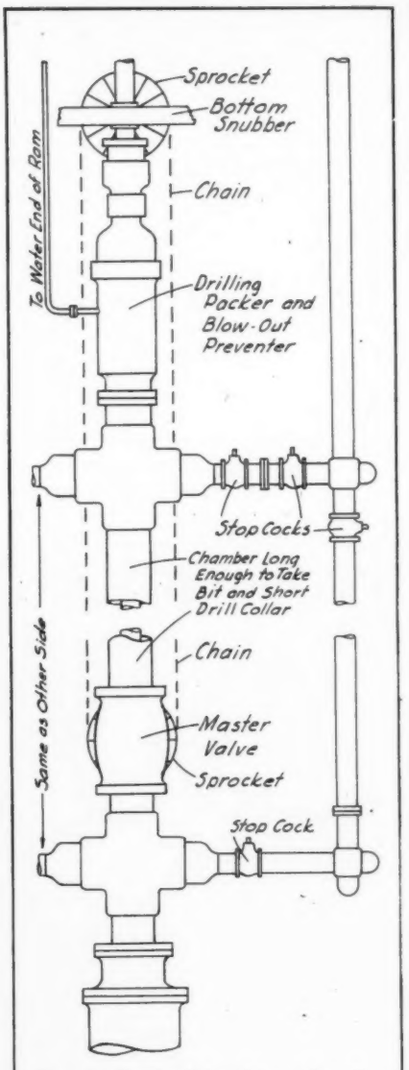


Fig. 1. Typical hook-up showing high pressure surface connections

Mud Circulation

Six mud pumps, two for pick-up and four for boosters, were used and were so manifolded that any number of five of the six could be in service at one time and could be compounded in any manner to supply the necessary pressure to the circulating fluid. The pump connections can be seen in accompanying photographs.

An advantage of closed circulation was that only one pump was used and wear and tear on the others thus eliminated. When using closed circulation the pressure was increased to well above the drilling pressure. Some formations would take mud and these had to be watched and provided for.

The upper snubber during the snubbing in of a string of 5-in. O.D. casing

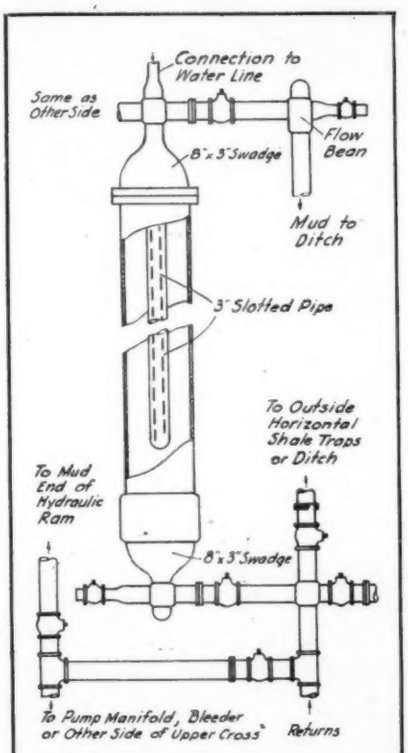

Connection to Water Line
Same as Other Side
Flow Bean
8"x 3" Swadge
Mud to Ditch
3" Slotted Pipe
To Outside Horizontal Shale Traps or Ditch
To Mud End of Hydraulic Ram
8"x 3" Swadge
To Pump Manifold, Bleeder or Other Side of Upper Cross
Returns

Fig. 2. Vertical shale trap (elevation)

Closed-in hole pressures during the drilling of the high pressure zone ranged from 2200 to 2400 lb. per sq. in.

Mud returns left the casing through the mud cross below two control heads, as shown in Fig. 1. As the mud went directly to the pumps when using a closed system or through beans when holding a back pressure on the fluid stream, cuttings had to be removed by means of shale traps. There were four of these traps, two vertical and two horizontal. The vertical traps, shown in Fig. 2, extended 5 ft. above the derrick floor and the horizontal traps, shown in Fig. 3, were placed outside the derrick.

The mud line leaving the cross on the casing carried the returns to the shale traps by means of crosses placed in the line. Control of flow to the traps was provided by stop cocks and the stop cock that controlled the flow between the vertical and horizontal traps was operated from the derrick floor by a long-handled wrench set on the stem of the valve.

Downstream from a stop cock, placed near the casing cross and used to shut off close to the hole, was a tee with a take-off that supplied pressure to a hydraulic ram. This ram rested on the derrick floor, as can be seen in accompanying photographs.

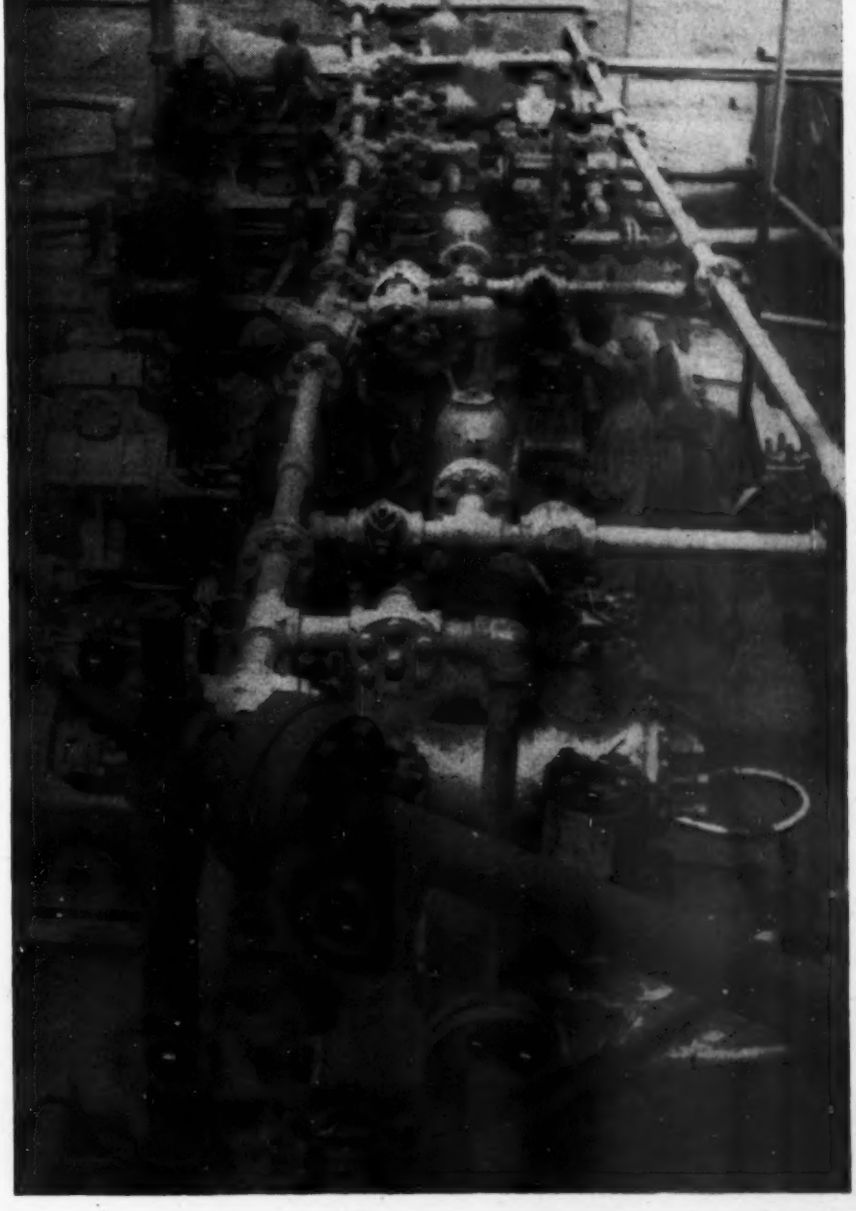
Hydraulic Ram

The hydraulic ram was constructed with a cylinder and piston at each end, the cylinder being connected by a piston rod. The cylinder nearer the hole was connected directly to the hydrostatic head with 1-in., heavy-duty pipe and water was used for operation. The gauge, bleeder, and all controls were placed at the ram end. The cylinder at the opposite end was connected to the mud stream, tying in with input and output circulation. This was provided with approximate stop cock control and correctly placed unions for possible repairs without shutdown.

The ram provided hydraulic pressure to the control heads when they were put into service and caused the rubber in these heads to close around the pipe. Additional power of approximately 500 lb. per sq. in. was given to the ram by an adjustable weight that can be seen below the derrick floor in the picture of the ram. Unless the pack-off rubber in the hydrostatic head was faulty and required additional outside pressure to make it effective, the mud end of the ram was left open to return circulation pressure plus the additional pressure supplied by the adjustable weight.

Drill Pipe

When drilling under pressure only round flush joint drill pipe passed



Pumps and pump connections used for high pressure drilling in the Khaur field, India

through the drilling packer although rotation of the drill string was through a square kelly. This was accomplished by means of a rotating housing that extended a kelly length above the table by which it was rotated. The top of this housing was flared and in the bell so formed was a seat for a square-holed bushing. The kelly moved downward through this bushing causing it to rotate. The operation was the same as if the table were a kelly length above the derrick floor and this arrangement eliminated the necessity for the kelly to pass through the drilling packer.

Flush joint drill pipe was used while drilling under pressure and had to be snubbed in and held back when going in and coming out of the hole, respectively. Top and bottom snubbers were used for these purposes, the top snubber being shown in the photographs and the bottom snubber indicated in Fig. 1.

After drilling through the high pressure water sand, which approximates 500 ft. in thickness, a string of 7-in. flush joint casing was run and cemented from the shoe to the surface. This casing obviously had to be snubbed in until its weight overcame the pressure to which it was subjected.

In some cases the 8⅝-in. casing did not stand up satisfactorily and thus could not maintain the pressures necessary when drilling through the water sand. If a hole was worn in the 8⅝-in. casing, or it collapsed, it could usually be straightened and recemented. If this could not be done, a string of 7-in. flush joint casing was set and cemented above the sand and 5⅝-in. hole carried through the high pressure zone with 3-in. flush joint drill pipe. A string of 5-in. flush joint casing was then set below the high pressure zone and cemented to the surface.

Tool Joints Released From Priority Control

Tool joints now may be ordered from suppliers without obtaining preference ratings, the Petroleum Administration for War announces. Future procedure will be similar to that now used to procure rotary bits.

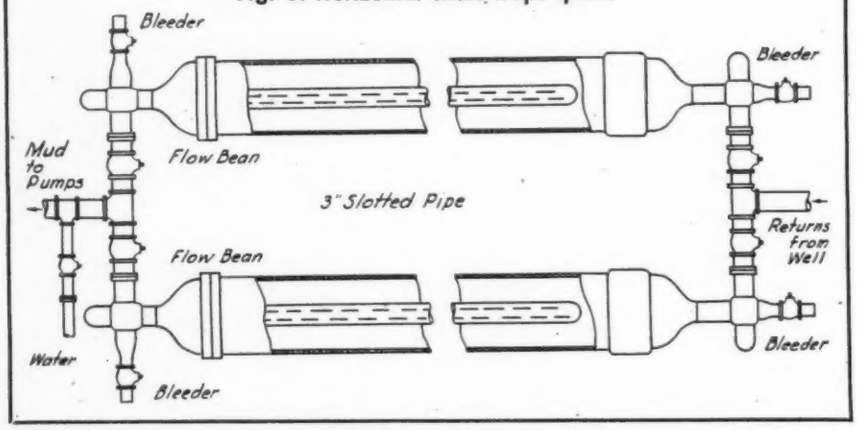
Commenting on the amendment to Preference Rating Order P-98-b, Deputy Administrator Ralph K. Davies said:

"Tool joints are used only in the production branch of the petroleum industry. Since they are specialized items, they have no use outside the industry. They are produced by manufacturers of specialized petroleum production machinery and equipment, and the controlled material for their manufacture is made available by the Petroleum Administration, acting as an industry division of the War Production Board.

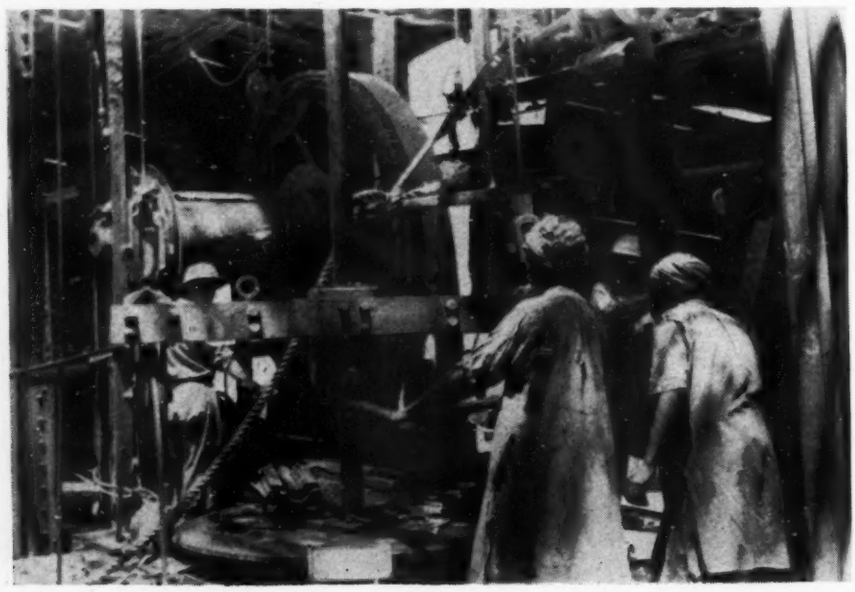
"At the present time, tool joint manufacturers are faced with a ten-month backlog of orders. Current production is sufficient to fill the more urgent requirements, and, through this amendment to P-98-b removing preference rating requirements on tool joints, it will be possible for PAW to supervise distribution of these items, diverting them from the less urgent to the more urgent needs.

"In this manner available supplies will be utilized where they will do the most good. This is particularly important in view of the current program which contemplates the drilling of 24,000 wells this year."

Fig. 3. Horizontal shale traps (plan)



The upper snubber at the completion of snubbing in 5-in. flush joint casing



Completing Well

The hole was completed under fluid control and not with pressure drilling after the high pressure water zone had been cased off. The mud circulated during this drilling was maintained at not less than 90 lb. per cu. ft. and weight material was used during the drilling of this portion of the hole. The size of hole was 5⅝ in. when 7-in. casing had been cemented through the high pressure zone and 3⅞-in. when it was necessary to use 5-in. casing. In some of the early wells, 5¾-in. liner was run below the 7-in. casing or 4-in. liner below the 5-in. when it had to be used. The later wells, however, were brought in barefoot.

Data and photographs used in this article were supplied by Karl B. Jauman, who was formerly with the Attock Oil Company, Ltd., in the Punjab fields.

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Well Spacing—Its Effect On Recoveries and Profits

PART 2

by Stuart K. Clark and J. S. Royds
Continental Oil Company
and
C. W. Tomlinson
Independent Operator

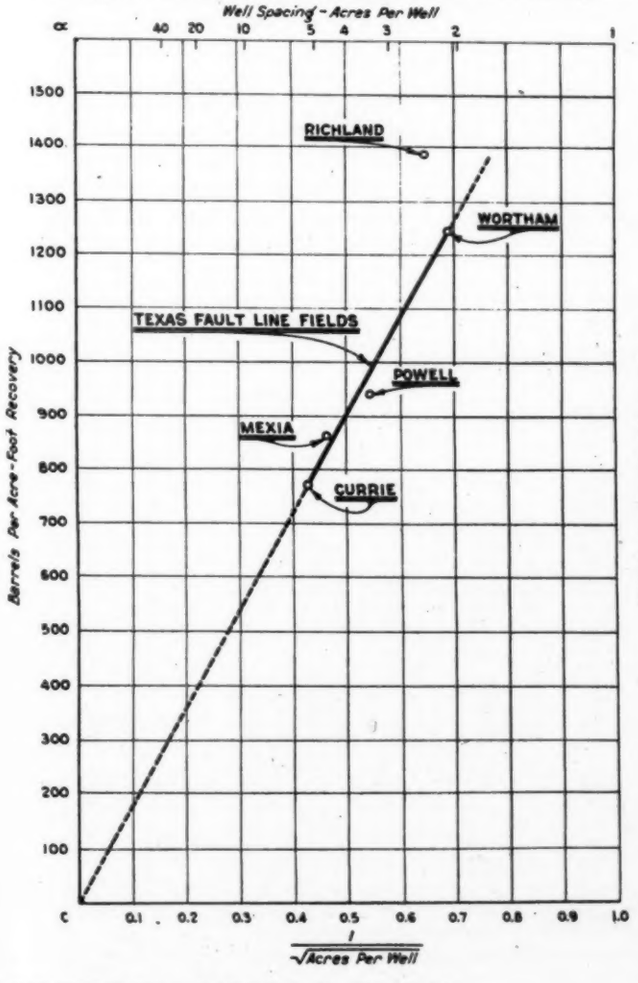
THE foregoing suggests the possibility of utilizing a graphic chart, in which recoveries per acre foot of pay and the reciprocal of the square root of the acres per well are used as the coordinates, to show that mathematical relationship. Fig. 3 presents such a chart, on which the points for the Texas fault line fields have been plotted.

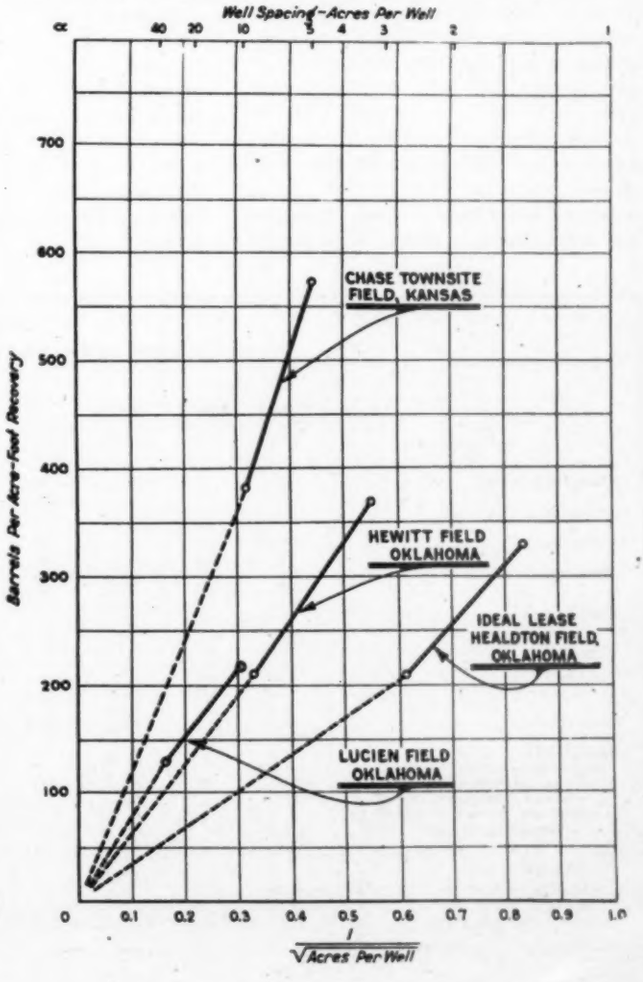
The data for the Wortham, Mexia, and Currie fields fall almost in a straight line, the projection of which passes through the zero point of the two scales. The Powell field point falls only slightly below the line. Only the Richland field point lies appreciably out of line. When the difficulties of determining pay sand volumes precisely and the possibilities for variations in the reservoir rock itself are considered, these data may be regarded as perfect evidence of the suspected straight line relationship.

The importance of these data in their bearing on the problem can hardly be overemphasized, since they probably represent the most conclusive evidence that has been, or is likely to be, assembled as to the exact effect of variation in well spacing alone on unit recoveries.

The meaning of the relationship shown by the graphic chart may be

Fig. 3 (left) and Fig. 4 (right) illustrate relationship between well spacing and recovery in specific instances


Well Spacing - Acres Per Well
∞ 40 20 10 5 4 3 2 1
RICHLAND
WORTHAM
TEXAS FAULT LINE FIELDS
POWELL
MEXIA
CURRIE
Barrels Per Acre-Foot Recovery
1500 1400 1300 1200 1100 1000 900 800 700 600 500 400 300 200 100
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
1/√Acres Per Well


Well Spacing - Acres Per Well
∞ 40 20 10 5 4 3 2 1
CHASE TOWNSITE FIELD, KANSAS
HEWITT FIELD OKLAHOMA
IDEAL LEASE HEALDTON FIELD, OKLAHOMA
LUCIEN FIELD OKLAHOMA
Barrels Per Acre-Foot Recovery
700 600 500 400 300 200 100
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
1/√Acres Per Well

made clear with the aid of the well spacing-acres per well scale drawn at the top of the chart. The unit values on this scale represent an inverted diminishing series approaching the zero of the horizontal scale as the spacing approaches infinity. Then, if a straight line passing through the zero point of the chart represents all the variations in recovery from a given reservoir, or from identical reservoirs, for all possible variations in well spacing, other factors being equal, it means that as well spacing increases unit recoveries decrease in inverse ratio to the square root of the spacing as expressed in terms of acres per well, and that as the spacing approaches infinity the unit recovery approaches zero.

The conclusive demonstration provided by these data from separate fields that well spacing, even with densities below 6 acres per well, does affect recoveries in accordance with a definite mathematical relationship, makes a huge volume of supporting evidence based on different spacings in the same field admissible.

A number of such cases are shown on a second chart (Fig. 4) and following charts.

Lucien Field, Oklahoma

The Lucien field data (Fig. 4) are of particular interest, since the initial development was undertaken as a unit operation under proration and the greater part of the field was developed with a spacing of 40 acres per well, with the avowed purpose of making the field a model of economical development and efficient operation.

Several years later a south extension was developed on a minor dome at the south end of the major structural high. It was largely developed on a 10-acre spacing pattern. Both areas produce from both the First and Second Wilcox sands (Ordovician).

Production from the first and second sands has not been segregated, but the productive portions of the two horizons in this field appear to be almost identical in character.

It is noteworthy that the line joining the 40-acre and 10-acre recovery points, if projected, passes only slightly above the zero point of the chart. Or, from another viewpoint, the recovery from the 10-acre wells is slightly less than would have been indicated by a line from the zero point to the 40-acre datum.

Wanted by U. S.—An Oil Policy

The United States is entering a period when we must consider a petroleum policy; it is not proper that that policy shall be determined by executive action alone, although if we do not now consider it, if the matter proceeds along the present lines, we shall be practically committed to a policy which has some very extensive ramifications.

—Truman Subcommittee, U. S. Senate.

The real solution to our petroleum problem may well be the active and firm diplomatic support to the commercial efforts of our own nationals abroad, rather than the policy of imperialism that is being proposed by some of our executive and administrative officials.

—Andrew Rowley, Tulsa Tribune.

Autocratic bureaucrats, entirely inexperienced in world affairs or matters relating to petroleum industry developments, may easily cause serious trouble for this nation, embroil us in difficulties with other nations and seriously handicap efforts of American nationals to develop oil resources abroad which have been procured by private enterprise.

—Andrew Rowley, Tulsa Tribune.

The specific figures used are set up in Table 3.

Hewitt Field, Oklahoma

The data for the Hewitt field (Fig. 4) provide another near perfect confirmation of the proposition that recovery is inversely proportional to the square root of the well density expressed in acres per well. One point represents an area of 790 acres in the north portion of the field with a spacing of 9.6 acres per well and the other represents the remainder of the field with an average spacing of 3.3 acres per well.

The economic importance of close spacing in this instance is indicated by the fact that some 32,000,000 bbl. of

TABLE 3

Summary of intra-field data used in well spacing—recovery chart

	Number producing wells	Number productive acres	Density, acres per well	Average sand thickness, ft.	Number acre ft. pay	Produced 1-1-43	Estimated ultimate production	Cumulative recovery		Estimated ultimate recovery	
								Barrels per acre	Barrels per acre ft.	Barrels per acre	Barrels per acre ft.
Chase Townsite field	25	125	5	est. 25	3,125	1,720,672	1,799,038	13,765	549	14,392	575
	121	1210	10	est. 25	30,250	10,596,912	11,749,906	8,758	350	9,630	385
Lucien field†	32	354	11.0	125	44,554	8,021,564	9,620,000	22,659	180	27,175	215
	76	2770	36.4	71	196,204	20,814,819	24,585,000	7,515	106	8,875	127
Hewitt field	612	2020	3.3	104	210,080	73,669,400	77,900,000	36,470	350	38,564	370
	82	790	9.6	97	76,630	15,049,500	16,070,000	19,050	196	20,341	210
Mexia field	264	873	3.3	58.6	51,189	54,209,410	56,500,000	62,067	1059	64,690	1104
	133	579	4.3	43.2	24,994	20,999,368	22,000,000	36,120	840	38,029	880
	127	947	7.45	55.3	52,354	30,637,798	33,000,000	32,370	585	34,865	630
Wortham field	76	137	1.8	19.8	2,713	....	4,707,250	..	..	34,359	1735
	134	257	1.9	27.3	7,016	....	10,721,449	..	..	41,718	1528
	80	177	2.2	25.9	4,584	....	5,018,514	..	..	28,353	1095
	64	189	3.0	24.1	4,555	*	3,052,787	*	..	16,152	670
Currie field	41	190	4.65	22.2	4,219	3,978,517	*	20,954	943	*	..
	17	163	7.18	16.4	2,689	1,497,773	....	9,134	557	..	..
	8	76.8	9.6	21.1	1,622	749,027	....	9,727	461	..	..
Richland field	58	124.9	2.15	20.9	2,618	3,868,782	3,970,450	30,869	1477	31,789	1517
	41	109.1	2.66	19.1	2,083.8	2,529,550	2,529,550	23,186	1214	23,186	1214
Healdton field:											
Ideal Scoggins lease—											
Original development, 1913-21	9	25	2.8	95	2,375	....	503,500‡	..	..	20,140	212
Additional development, 1928-41	17	..	1.5	..	..	....	783,750‡	..	..	31,350	330
Additional recovery attributed to denser spacing and gas injection	..	..	..	..	..	....	280,250	..	..	11,210	118

*Data not available.

‡Calculations based upon study of decline curve.

†Six leases including 11 wells in the east half section 33-20N-2W; NW quarter 34-20N-2W and NW quarter section 3-19N-2W are not represented on the chart. Production data were not available for the two wells in the NW quarter section 3. The other leases were excluded because of unsegregated Layton sand production.

oil must be credited to the effect of close spacing. That is, it represents the additional oil recovered to date from the closely spaced portion of the field beyond the unit recovery established for the widely spaced portion.

Healdton Field, Oklahoma

The data for the Ideal Oil and Gas Company and 32nd Oil and Gas Company's Scoggins lease in Section 32, Township 3 South, Range 3 West, (Fig. 4) present a different situation than that previously discussed. In this instance, one point represents the estimated ultimate recovery from 9 wells drilled during the period from 1914 to 1920 with a spacing of 2.8 acres per well, whereas the other represents the estimated ultimate recovery from 17 wells in the same area, including 8 drilled during the period 1936-41 making the spacing 1.5 acres per well. Contemporaneous with the additional drilling, some repressuring with gas was undertaken. This probably accounts for the fact that the indicated increase in recovery for the closer spacing is greater than the normal expectancy.

This is merely one instance out of the many that might be cited from the Healdton field, where 30 years' production history has conclusively demonstrated the advantages of close spacing.

Chase Townsite, Kansas

The Chase townsite pool, Kansas, (Fig. 4) presents a case somewhat similar to that of the Hewitt field, in that the townsite area in the north end of the field was developed on a spacing averaging 5 acres per well as compared to 10-acre spacing in the remainder of the field. The recoveries per acre, actual and estimated ultimate, are shown in Table 4.

So far as it can be determined, the average thickness of pay in the two areas is approximately the same. Precise computation of the actual volumes of pay in this porous dolomite are impossible. The unit recoveries plotted on the chart were computed on the basis of an average of 25 ft. of pay, which is approximately the average thickness of Arbuckle lime present above the original water level. This simply serves to give figures that fall within the range of the chart. The resulting comparison is precise as to acre yields and is believed to be relatively fair as to unit volume recoveries.

The increase in recovery per acre for the closer spacing is obvious. The recovery for the 5-acre wells is somewhat higher than would have been predicted on the basis of a line through the zero point and the 10-acre recovery point; but the agreement is close enough to confirm substantially that mathematical relationship.

EDITOR'S NOTE: This article will be continued in an early issue of *The Petroleum Engineer.*

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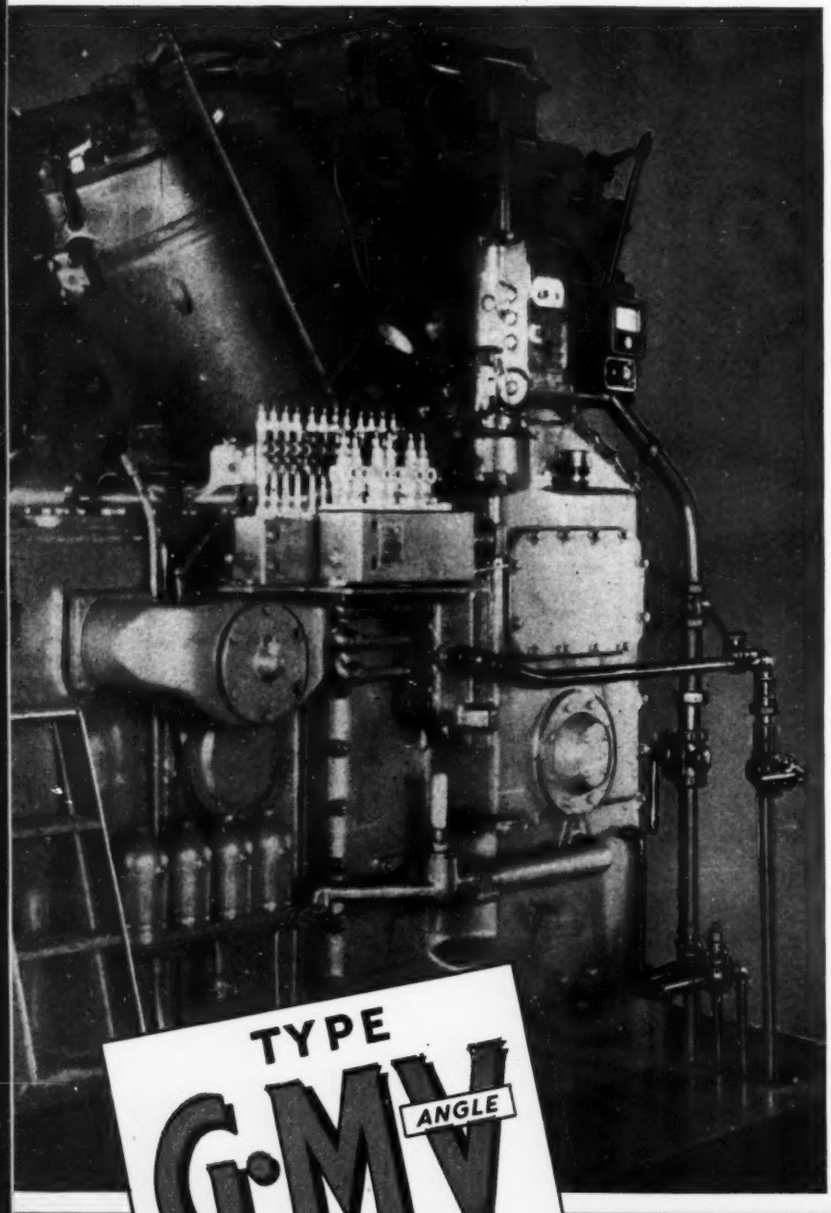
TABLE 4
Wilcox sand recoveries
Oklahoma City field

Spacing interval	Quarter section	Total number wells	Number effective acres	Density, acres per well	Number acre ft. pay	Cumulative 6-1-43	Estimate ultimate	Ultimate bbl. per acre ft.
0-4 acres per well	SW 14-12N-3W	1	1	1	113	174,878	220,000	1946*
	SE 34	44	160	3.6	30,345	42,544,627	50,000,000	1647
	NW 2-11N-3W	49	150	3.1	10,213	25,626,705	25,800,000	2526
	NW 10	42	160	3.8	32,302	20,449,832	23,450,000	725
	SE 15	24	83	3.5	4,790	8,758,757	9,100,000	1900
	SE 22	55	155	2.8	16,220	14,341,736	14,920,000	920
4-8 acres per well	SE 15-12N-3W	18	137	7.6	25,130	2,187,178	2,500,000	100
	NE 22	31	160	5.2	33,683	8,508,908	9,100,000	270
	NW 23	10	42	4.2	7,246	5,410,564	8,300,000	1145
	SE 22	32	160	5	35,251	21,723,131	23,875,000	677
	SW 23	24	107	4.5	21,038	16,062,764	19,200,000	912
	NW 26	13	57	4.4	3,612	2,011,500	2,100,000	581
	SE 27	26	160	6.2	25,141	12,394,587	15,350,000	610
	NE 34	30	160	5.3	28,063	21,239,403	26,300,000	937
	NW 3-11N-3W	30	156	5.2	27,428	18,356,317	19,400,000	700
	NE 3	28	157	5.6	23,065	38,802,732	42,640,000	1848
	SE 3	25	156	6.2	13,162	8,628,255	8,925,000	678
	SW 2	9	53	5.9	1,615	881,155	881,155	545
	NE 10	27	152	5.6	14,418	17,104,989	18,150,000	1258
	SW 10	25	134	5.4	21,648	9,650,428	12,100,000	558
	SE 10	15	111	7.4	10,850	9,075,989	9,360,000	862
	NE 22	15	105	7.0	3,830	2,771,736	3,010,000	785
8-12 acres per well	SW 22-12N-3W	20	160	8	24,170	6,157,837	9,300,000	384
	NW 27	14	158	11.2	25,491	8,073,222	10,500,000	411
	NE 27	18	160	8.9	22,886	12,122,655	14,425,000	630
	NW 34	16	138	8.6	18,572	3,565,941	7,000,000	376
	SW/4 34	20	160	8	25,737	9,980,218	12,100,000	470
	SW 35	12	128	10.6	9,174	3,933,463	4,160,000	453
	SW 3, 11N-3W	20	160	8	28,327	7,708,619	8,375,000	295
	NW 15	13	145	11.1	20,576	7,017,875	7,950,000	386
	NE 15	14	120	8.6	14,535	7,337,902	8,425,000	579
	SW 15	16	151	9.4	16,742	5,438,865	7,050,000	421
	SW 22	15	157	10.5	15,033	7,001,987	7,500,000	498
	NE 27	14	147	10.5	19,691	5,374,148	6,060,000	307
12-16 acres per well	SW 27-12N-3W	8	117	14.6	13,508	2,241,551	4,100,000	303
	NW 35	5	64	12.8	3,002	1,389,940	2,100,000	700
	Total South End area—SE 27, NW, SW and SE 26; NW, NE, SE 35; S/2 25; all sec. 36; NW, SW, and SE 31-11N-2W; SW 32-11-2; N/2 6-10N-2W	103	1306	12.6	143,303	37,807,611	45,750,000	320
More than 16 acres per well	NW 22-11N-3W	6	100	16.7	5,361	1,029,187	1,190,000	221
	SW 23	2	35	17.5	1,412	362,733	362,733	256
	SE 4	2	64	32	4,022	70,000†	70,000†	17*
	NW 27	1	56	56	3,026	95,000	95,000	31*
	NW 22-12N-3W	2	145	70.3	12,862	164,228	200,000	16*
Undrilled quarter sections	NE 15-12N-3W	..	105	....	8,112	.....	.....	....
	SW 15	..	98	....	6,047	.....	.....	....
	NE 21	..	7	....	74	.....	.....	....
	SE 21	..	51	....	1,489	.....	.....	....
	NE 28	..	42	....	1,789	.....	.....	....
	NE 33	..	8	....	149	.....	.....	....
	SE 33	..	56	....	2,867	.....	.....	....
	NE 4-11N-3W	..	108	....	9,363	.....	.....	....
	NE 9	..	65	....	4,301	.....	.....	....
	SE 9	..	37	....	1,678	.....	.....	....
	NE 16	..	16	....	421	.....	.....	....
	SE 16	..	28	....	983	.....	.....	....
	SE 27	..	....	....	2,239	.....	.....	....

*Sand volumes attributed to these wells probably in error. †Plus or minus.

Diesel

OPERATES AT TOP EFFICIENCY ON EITHER FUEL



THE Cooper-Bessemer Type G-MV has long been recognized as an outstanding power unit for oil field, pipe line and refinery service. Now, by virtue of practical research, skillful engineering and design, the G-MV is being built for either diesel or gas operation. With either fuel, this engine runs at top efficiency, with no change in rating or speed.

Only four simple steps are necessary to convert from gas to diesel:

1. Remove the electrical ignition.
2. Remove the gas injection system.
3. Add diesel fuel injection pumps.
4. Add diesel fuel system.

To convert from diesel to gas

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FOR COMPRESSORS. PUMPS. GENERATORS

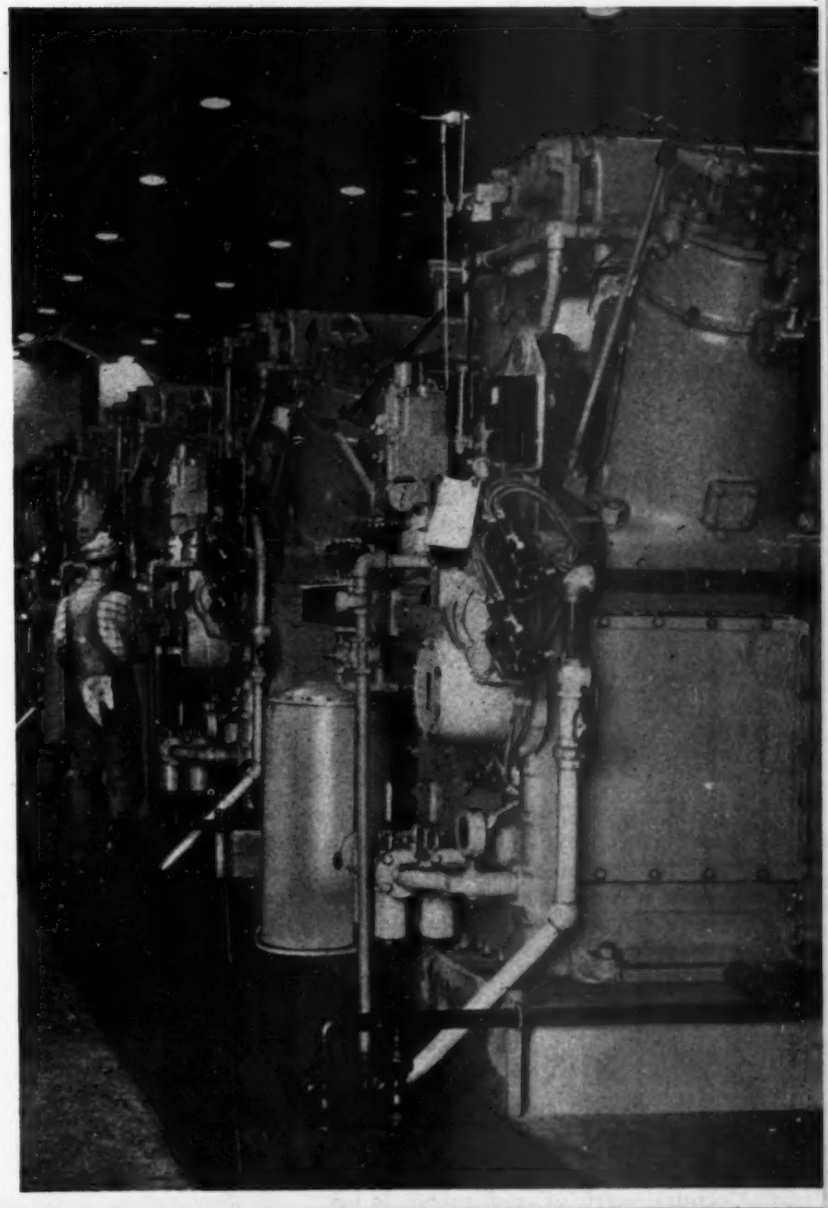
or Gas

. . . CONVERSION IS SIMPLE, EASY AND QUICK

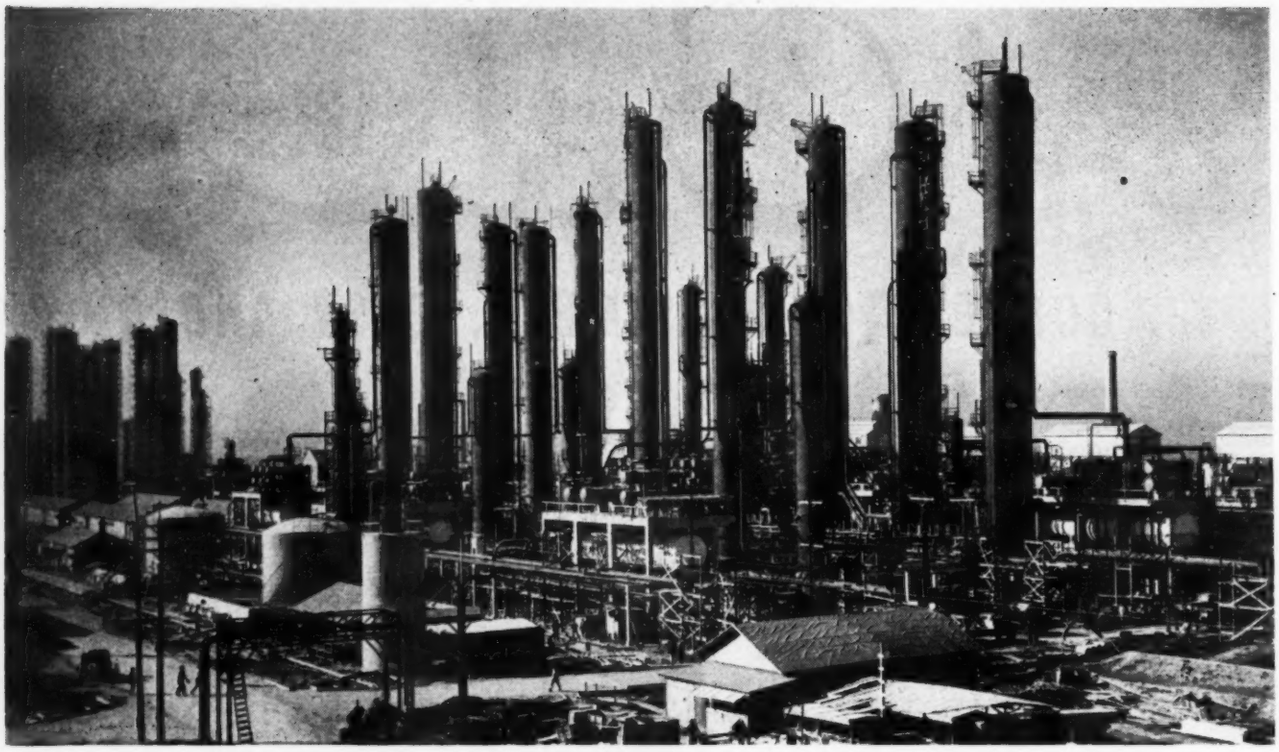
is just as easy — merely reverse the steps indicated.

The ability of the G-MV to operate on either fuel permits greater flexibility of operation and will result in increased operating economies. Especially in war plants, faced with the problem of converting to peacetime work after the war, this feature will prove of value.

This feature is just one of many advantages that distinguish the G-MV. Rugged and simple in construction, requiring minimum floor space, it is built to stand up under years of continuous operation, with minimum time out for maintenance or repairs. No wonder the Cooper-Bessemer G-MV is known and preferred by operators who want dependable, low-cost power.



Cooper-Bessemer



Neches Butane Products Company butadiene plant. Some of the towers are 17 stories high

Largest U. S. Petroleum Butadiene Plant

PETROLEUM ENGINEER Exclusive Feature

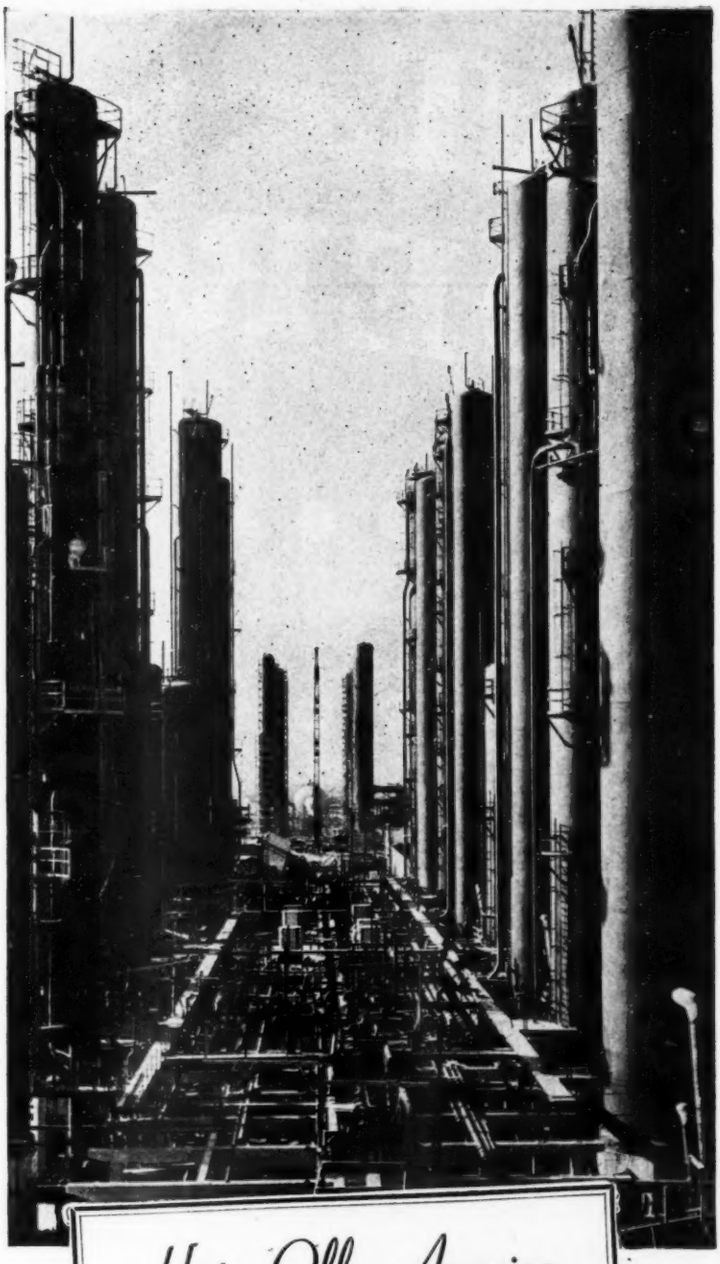
☆ **Operated by five major oil companies, plant will supply one-seventh of U. S. synthetic rubber**

by C. C. Pryor
Associate Editor

CAPACITY production of the Neches Butane Products Company plant at Port Neches, Texas, is expected early this year with completion of a second unit utilizing the latest butadiene production process. Designed as one of the world's largest plants to make butadiene from petroleum, with a capacity of 100,000 tons per year, plans for the Port Neches plant began in January, 1942, when Herbert Henderson, vice-president of Gulf Oil Corporation, was called to confer with government officials about the then critical supply of crude rubber. In line with the government plan to build a number of plants to produce butadiene from alcohol and petroleum, Henderson suggested the Port Neches plant. Henderson's plan was to build the 100,000-ton capacity plant near other large refineries in the Port Neches area to obtain feed stock; to obtain construction supervision and operation by five major oil companies without management fee, and to supply technical and other personnel for operating the plant. This plan was approved by the five oil companies and the government. The five oil companies engaged in directing operation of the plant are the Gulf Oil Corporation, The Texas Company, The Pure Oil Company, the Socony-Vacuum Oil Company, and the Atlantic Refining Company. These companies agreed to supervise construction and operation of the plant without profit and to supply the government the services of management, advisory, technical, and legal committee members and to pay their expenses.

Before Pearl Harbour three of the five refineries supplying the plant were already making 100-octane gasoline with expansions of capacity underway. During the early months of the war contracts were made with the five refineries tending toward an eventual production in existing equipment and in new equipment of an amount of 100-octane gasoline in excess of 10 per cent of the entire gasoline program.

As none of the five companies had previous experience with the production of butadiene, other refining companies, who had carried on intensive research on the subject for several years, agreed to exchange technical information with representatives of the five companies. As a result of the exchange the Port Neches plant was recommended. In addition construction of two copolymerization plants adjacent to the butadiene plant was recommended by the government to utilize the butadiene at its source.



Hats Off, America

TO:

ATLANTIC GULF

MAGNOLIA

PURE TEXACO

Again,

THE OIL INDUSTRY COMES THROUGH

From the very beginning of the National Emergency the oil industry has measured up heroically to our country's urgent and increasing demands for petroleum products.

An outstanding example of the industry's contribution to the war effort is the Neches Butane Products Company which brought the greatest of synthetic rubber developments into being on the Texas plain just south of Port Neches.

To the men who conceived and carried this plant to completion we offer our congratulations and extend best wishes for continuing success through the remainder of the war and into the peace that follows.

We, of Gulf States Utilities, are proud of our part in this great development. "Know how," born of long experience, has enabled us to measure up to the responsibility of furnishing vital electric power requirements for its construction and operation.

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COMPANY C	1	1	1	1	1		5 ORDERS
COMPANY D	1	1	1	6	1		5 ORDERS
COMPANY E	1	1	1	16			4 ORDERS
COMPANY F	1	1	2	1			4 ORDERS
COMPANY G	1	2	1				3 ORDERS

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Oil Industry Operated

The Neches Butane Products Company was organized with government approval by the five oil companies to manage the plant. It is the first entirely government-owned butadiene plant operated by the oil industry. The 100,000-ton production of the plant is sufficient butadiene to combine with styrene to make 110,000 long tons of synthetic rubber known as GR-S or buna S. This supply of butadiene will produce one-seventh of the entire wartime program of synthetic rubber in the United States.

Butadiene produced from a barrel of petroleum by processes used before the war yielded only about 2 per cent and the remainder of the barrel being used for the manufacture of regular petroleum products. Through the pooling agreement of the various companies a process was developed that utilized approximately 5 per cent of a barrel of petroleum, the rest being suitable for production of high octane gasoline and other products. Contract was awarded by the Defense Plant Corporation, subsidiary of Reconstruction Finance Corporation, to The Lummus Company for construction of the plant.

During construction of the butadiene plant, the Defense Plant Corporation constructed two copolymerization plants on adjacent sites. The copolymerization plants will combine the butadiene with styrene to produce synthetic rubber latex. One plant is to be operated by the B. F. Goodrich Company and the other by the Firestone Tire and Rubber Company. These plants are operated by the companies for the Rubber Reserve Company.

The refineries near the butadiene plant selected to supply it with feed stock expanded facilities to increase their production of the feed stock and aviation gasoline.

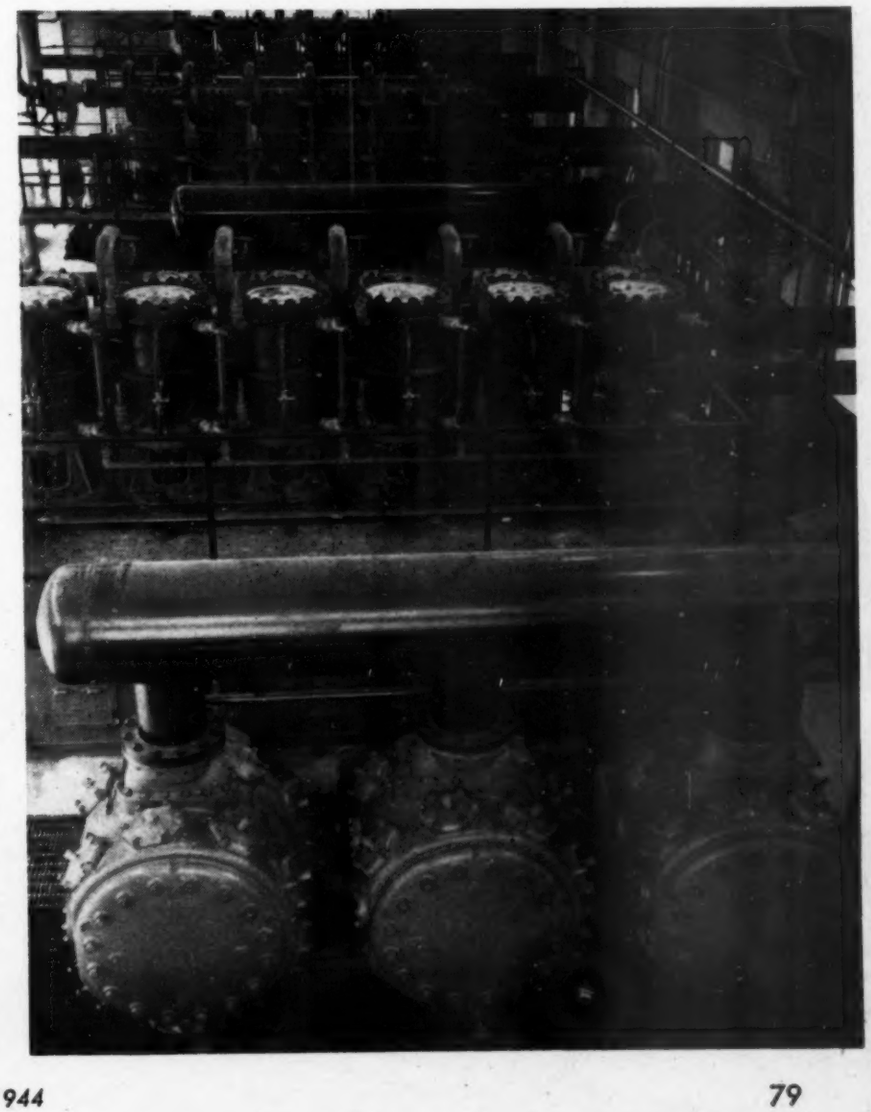
Construction

An area of 314 acres was required for the site of the butadiene plant. Construction of roads and drainage canals was required before actual work of erecting the plant could begin in June, 1942. One of the immediate problems that had to be overcome was the inability of the contractors to find a solid foundation for the 48 steel process towers of the plant. The problem was solved by sinking concrete piling 40 ft. in the marshy ground. Some of the towers are as high as a 17 story building. Foundations for other vessels and storage spheres were provided by sinking hundreds of smaller concrete piling. The butadiene plant has 42 storage spheres, a larger number of pressure storage vessels than previously used by any refinery. Largest of the storage spheres has a capacity of 12,000 bbl. of raw stock or finished butadiene. Foundations for other buildings and equipment also required piling, bringing the total number of concrete piling to over 11,000.

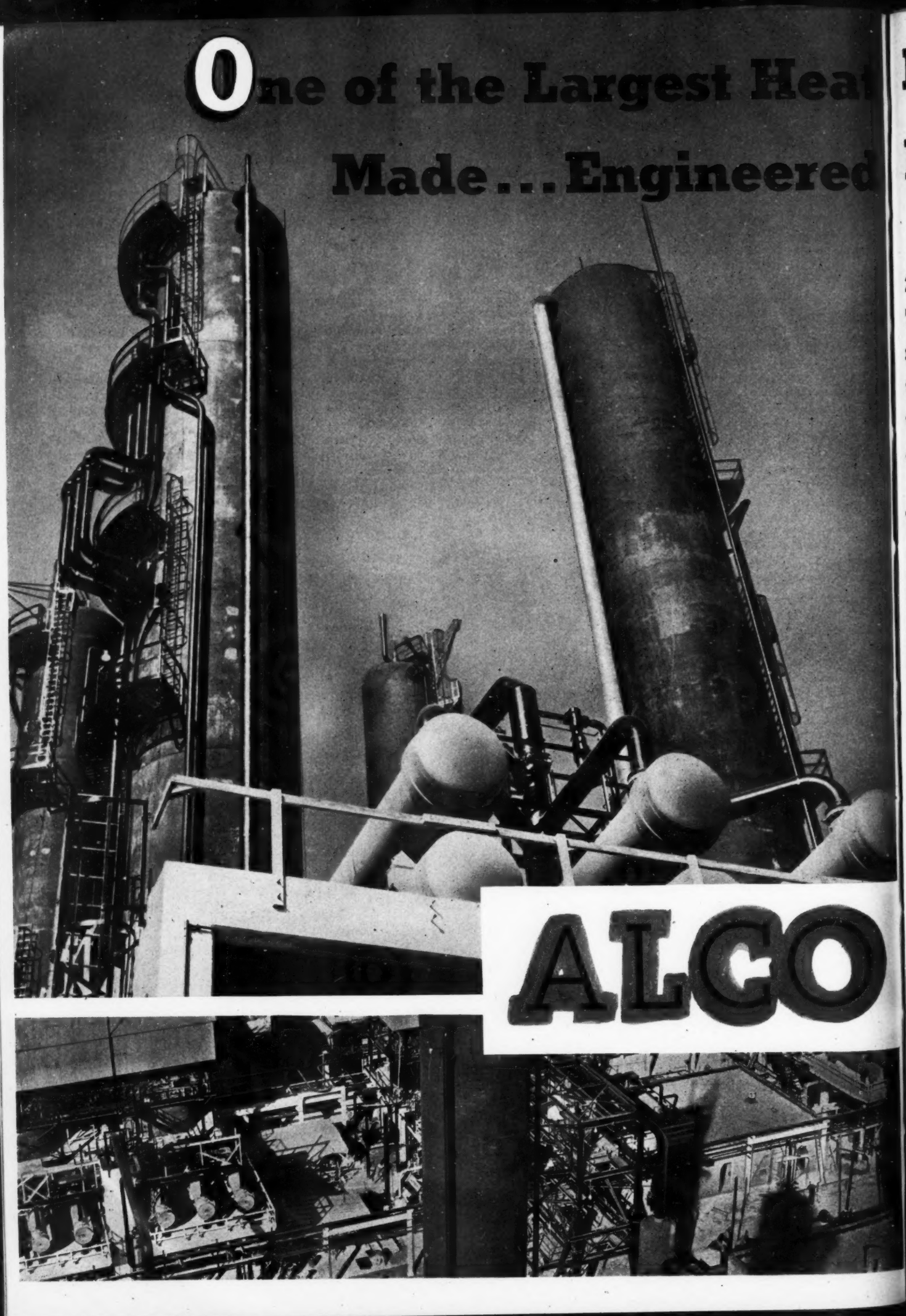
Water for the butadiene plant is pumped from the Neches River through a mile-long covered aqueduct. The aqueduct has its beginning at the river water pumping station and is pumped by specially designed pumps with adjustable feathered propellers at the intake. These propellers, similar to those of airplane design, con be adjusted electrically from the control room to regulate the volume of water pumped. The pump station and aqueduct have a capacity of 308,000,000 gal. per day of cooling water for the plant. The pumps are driven by natural gas engines. A canal returns the water to the river. In the plant a battery of 10 centrifugal pumps, each having 24,000 g.p.m. capacity, supply water to the various units.

Process tower fabrication was accomplished on the plant site. Engineers assembled steel rolling equipment, hydraulic presses and other equipment to set up a fabrication shop on the plant site. As a result all of the fractionating towers in the plant were fabricated in the plant shop on the site. Newly developed electric seam-welding equipment was used to reduce construction time on the vessels. Fractionation towers were built in one piece on cradles arranged on railroad trucks, rails were laid from the fabricating shop to the tower site, and the tower raised to its concrete foundation by derricks. Twenty-seven of the towers are in the North unit and remaining 21 in the South unit of the plant. The additional towers in the North unit constitute the purification section for solvents and was not duplicated in the South unit.

(Continued on Page 82)

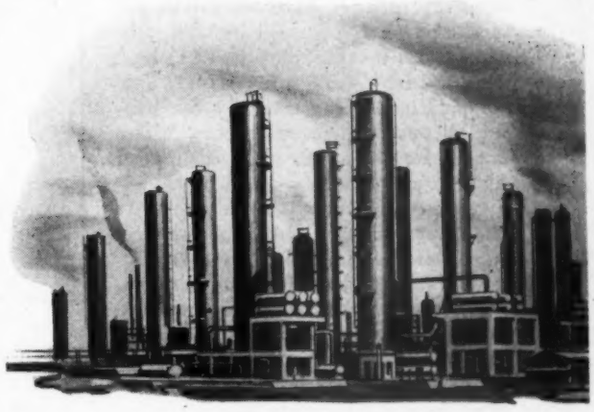


Steam driven compressors totaling nearly 12,000 b. hp. compress the gases passing from the dehydrogenation section to the butadiene purification section


One of the Largest Heat
Made...Engineered
ALCO

Exchanger Installations Ever by ALCO for Port Neches

294 heat exchangers—comprising nearly 700,000 sq. ft. of heating surface—engineered and designed by ALCO for installation at new Port Neches butadiene plant—without doubt one of the largest single orders for heat exchangers ever placed



WHEN the far-eastern rubber supply fell into the hands of the Japs after Pearl Harbor, this nation faced near disaster. The petroleum industry promptly joined in a huge national effort to avert the threat. Oil chemists in many companies pooled researches in order to find a way of re-forming the petroleum molecule to make it bounce.

Gulf Oil Corporation, Pure Oil Company, Magnolia Petroleum Company, The Texas Company, and Atlantic Refining Company united their endeavors to create an adequate source of butadiene—basic constituent of Buna S synthetic rubber. The Port Neches plant, designed and built by Lummus Company, to produce 100,000 tons of butadiene annually, resulted from this effort.

In this plant, as in all petroleum refining operations, heat exchangers perform a vital function. ALCO did the process engineering and detail engineering for all of these heat exchangers. ALCO also supplied forgings for many units. In all, ALCO engineered 294 heat exchangers, comprising nearly 700,000 square feet of heating surface—without doubt one of the largest single orders for heat exchangers ever placed!

ALCO Heat Exchangers, ALCO Pressure Vessels, and ALCO Prefabricated Piping are prominent in every field where dependable, modern equipment of these types is important. The wide use made of ALCO heat exchanger engineering skill and experience in the Port Neches plant is but one example of the high regard in which ALCO equipment, abilities and facilities are held. It is evidence of a trend—a reason why you can confidently turn to ALCO first, when you need heat exchangers, pressure vessels, or prefabricated piping.

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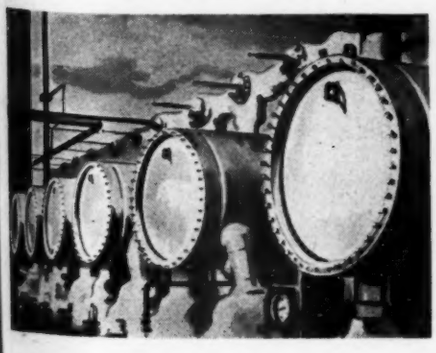
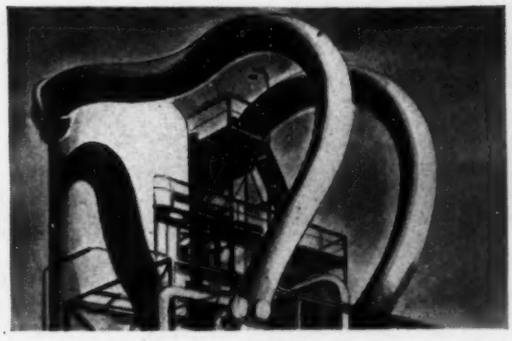
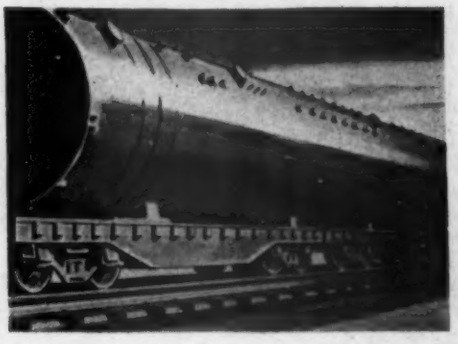


PREFABRICATED PIPING



PRESSURE VESSELS



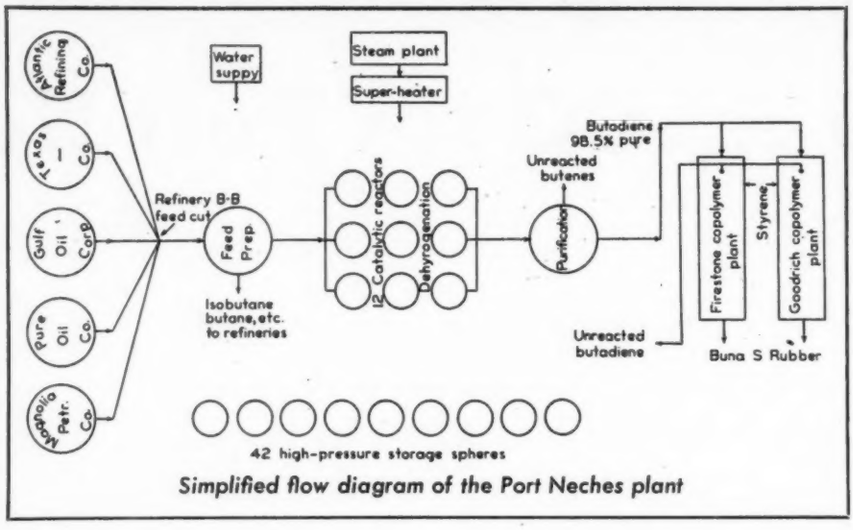
(Continued from Page 79)

Steam Supply

Steam is supplied for butadiene processing by a plant equipped with four large boilers having a combined capacity of 50,000,000 lb. per day. The steam plant is constructed on a foundation of concrete piling. Economical use of steam power is obtained by using the same steam for three purposes: (1) high temperature heating processes, (2) low temperature boiling, and (3) for driving all pumps and compressors. Water supply for the steam plant is supplied by a large water treating plant having a capacity to supply a sizable city. As the processing of butadiene requires superheated steam, a battery of superheaters was required. Steam at this temperature had not been used in industry previously and it was necessary to design a superheater plant. Superheated steam is supplied by the battery of superheaters taking steam from the central plant and reheating it.

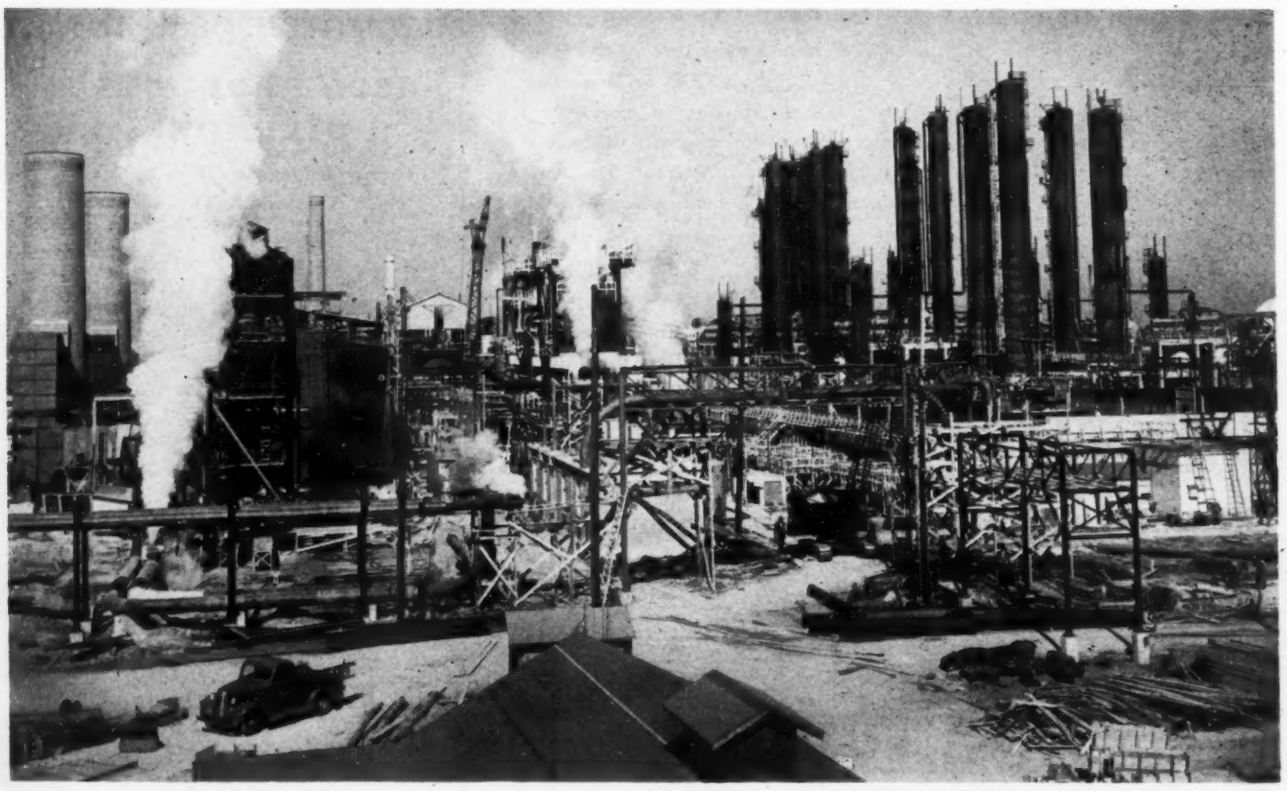
Row Feed Preparation

Raw feed stock for the butadiene plant as supplied by the refineries is actually a mixture of normal butane, *iso*butane, normal butylene, and *iso*-butylene. This stock, referred to as butane-butylene feed, reaches the plant by pipe lines from each of the refineries. It is metered at the refineries. Samples of the feed stock for analysis are also taken at the meter station by the butadiene plant employees. Contract prices for the butylene supplied to the Neches plant by the refineries are only a fraction of cent a pound more, a few cents more per gallon, then the wholesale price of premium motor gasoline at refineries in the area. The total volume to be supplied, about 4500 bbl. per day, is less than one per cent of the total daily output of refined petroleum products of the five participating petroleum refiners. The raw stock first enters the feed preparation section of the plant. In this section normal butane, *iso*butane, and *iso*butylene are separated from the normal butylene and returned to the refineries to be used in the production of aviation gasolines About two-thirds of the feed stock is returned to the refineries. Normal butylene, butenes 1 and 2, then pass to the dehydrogenation section. Separation of the raw feed stock is an extremely difficult operation due to the close boiling points of the hydrocarbons and special fractionation towers are required for separation of the various hydrocarbons. The butane-butylene feed is then separated by extractive distillation and solvent extraction



Simplified flow diagram of the Port Neches plant

Twenty-seven of the plant's 48 towers are in the north unit at right. At the left a steam super-heater unit nears completion



to recover the butene fraction for conversion to butadiene. Steam-driven centrifugal multi-stage pumps and reciprocating steam pumps are used in this part of the process. The feed preparation section has a capacity of 75,000,000 cu. ft. per day.

Dehydrogenation

The normal butylene stream enters the dehydrogenation section of the plant for conversion to butadiene by removal of two hydrogen atoms. This process converts a substantial portion of the butylene to butadiene. High temperature steam and a catalyst are required in the dehydrogenation process. There are 12 catalyst cases, which are on stream in one hour cycles—three pair operating and three pair regenerating the catalyst. Catalyst in the fixed bed type reactor cases is in pellet form. The high temperature steam is injected into the butylene stream to the catalyst reactors and as it is still in the butylene gas passing from the reactors, must be removed before the process can be continued. After the steam has been removed, the gas now containing some butadiene is cooled and compressed. Six 6-cylinder, steam driven, angle type, compressors, 1740 b. hp. units deliver a total of 10,440 hp. to compress the gases. The butadiene-butylene stream then enters the third section of the plant for purification, separation of the two components.

Butadiene Purification

Batteries of automatic instruments operated by compressed air control the reactor cycles, valving, temperature, and pressure of the various streams at all times. The controls transmit mechanical reports to the three main control houses and two supplementary control stations.

Separation of the butadiene and butylene is accomplished by special fractionation towers. The lighter fractions, C_1 and C_2, are used for fuel in the plant. After purification, the butylene gas is rerun through the dehydrogenation section for final conversion and the butadiene, 98.5 per cent pure, is stored or transferred by pipe line to the copolymerization plant. During the reaction with styrene and other components to produce synthetic rubber latex, all the butadiene does not react. This unreacted butadiene is stored at the copolymerization plant and then mixed with a fresh supply of butadiene going to the reactors. A portion of the unreacted butadiene is returned to the butadiene plant for further purification in the purification section.

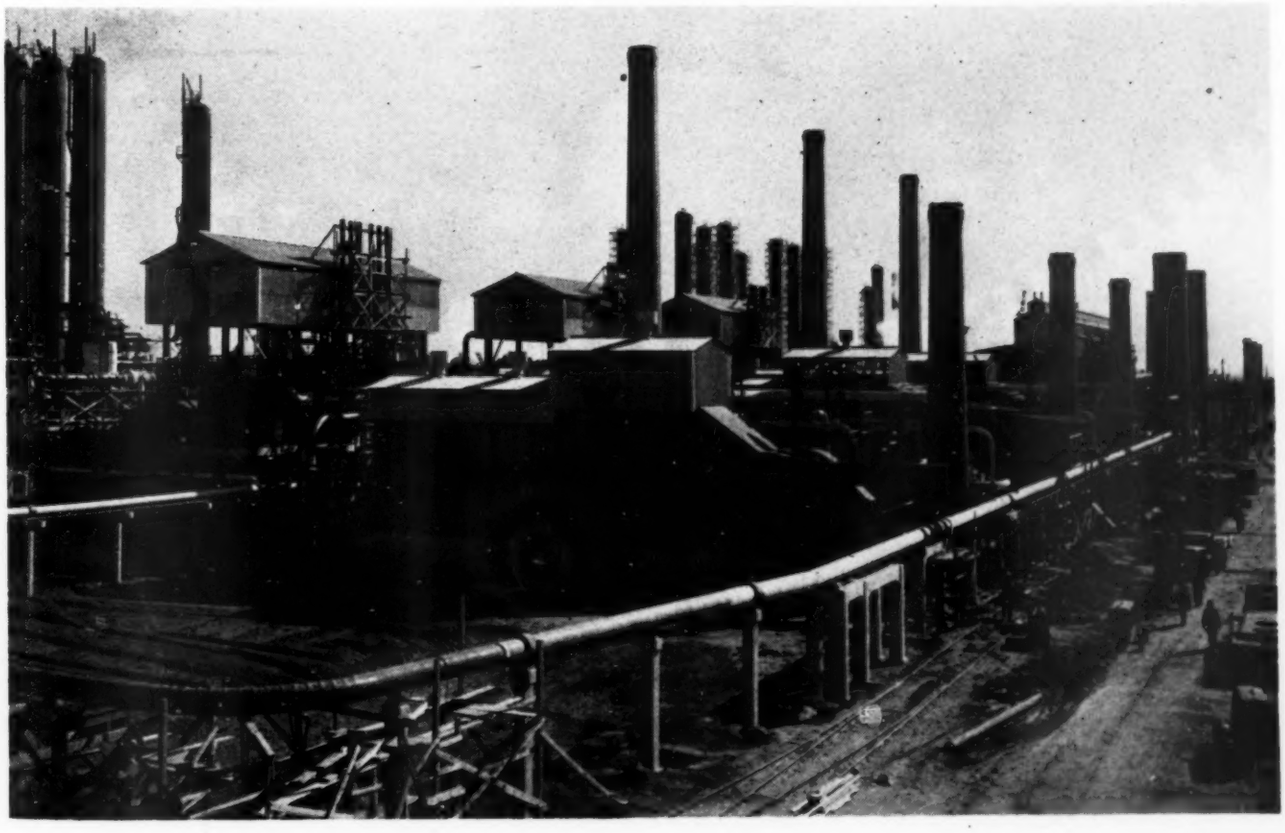
Six thousand workers were required to build the plant; however, only 800 workers will be needed to operate the plant on three, 8-hour shifts.

Directors of the company are as follows: E. J. Henry, vice-president and W. F. Stroud, The Atlantic Refining Company; W. A. Slater, vice-president, and Herbert Henderson, vice-president, Gulf Oil Corporation; C. B. Watson, vice-president and J. P. Langfitt, assistant to vice-president, The Pure Oil Company; W. F. Burt, director, and Dr. J. B. Rather, director of research, Socony-Vacuum Oil Company, Inc.; M. Halpern, vice-president and G. R. Bryant, general manager refining department, The Texas Company, and W. H. Hoffman, Neches Butane Products Company.

Officers of the Neches Butane Products Company are Herbert Henderson, chairman of the board; W. H. Hoffman, president; J. B. Rather, vice president; H. P. Arbuckle, secretary-treasurer, and F. W. Cooper, assistant secretary-treasurer. The technical committee consists of duBois Eastman, chairman, The Texas Company; P. W. Cornell, Gulf Oil Corporation; M. J. Fowle, The Atlantic Refining Company; J. Happel, Socony-Vacuum Oil Company, Inc.; C. A. Porter, The Pure Oil Company, and A. H. Schutte, The Lummus Company.

☆ ☆ ☆

General view of the utility section of the butadiene plant. Super-heaters in the foreground supply high-temperature steam to the dehydrogenation section



Hughes Oil Tool Production is Geared to Demands of War!

1,000,000 gallons of gasoline and 25,000 gallons of other petroleum products were burned by nearly nine hundred planes in a recent raid over Axis territory.

With thousands of tons of destruction being rained on Axis territory daily, war's appetite for oil continues to make ever greater demands on the Industry . . . demands that have necessitated a great increase in drilling activity.

Hughes part in this program is the "all-out" production of Rock Bits, Core Bits, Tool Joints and other specialized tools for the essential Oil Well Drilling Industry.

HUGHES TOOL COMPANY HOUSTON, TEXAS

Oil Well Cementing

PETROLEUM ENGINEER Exclusive Feature

PART 2 (Concluded)

by C. A. Pitts

Field Engineer, Halliburton Oil Well Cementing Company

DRILLING mud and cement slurries have the property of being able to form thixotropic[1] gels. As agitation will restore fluidity, the rate at which a gel forms determines the agitation necessary to maintain a given fluidity. Drilling mud when contaminated with cement has a higher gel rate than normally. Cement contaminated with drilling mud also has a higher gel rate than normally. When viscous flow conditions predominate, the rate at which the gel is broken decreases outward from the point of maximum velocity. When turbulent flow conditions predominate the rate at which the gel is broken is uniform throughout the turbulent area. A gel once broken by turbulent flow conditions will remain broken so long as turbulent flow conditions exist.

By applying this knowledge it is possible from an examination of the conditions of flow in cementing a well to determine what factors may be controlled to increase the Reynolds number and thus attain a more perfect cementing job.

After the cement is mixed and pumped into the well there is an unavoidable delay caused by placing the top plug and starting the rig pumps. If this time interval is too long the cement will stop moving at the point of hydrostatic balance between the columns of fluid inside and outside the casing. When the rig pumps are started and the drilling mud "catches up with" the cement, the cement begins to move and a high velocity can be maintained until the point is reached at which columns of cement inside and outside the casing are equal. A pressure greater than circulating pressure then becomes necessary to advance the cement upward behind the casing and from this point on, the velocity of the fluids in the annulus decreases, thus giving the cement a chance to gel. Once it gels, work must be done to break the gel and as it breaks, the flow is under viscous conditions, which means that movement will begin at some center, outward from which velocities will decrease to zero. At this center the velocity may be great enough to create turbulent flow conditions, although viscous flow conditions will prevail outward from the center. This condition undoubtedly leaves a film of contaminated material at the points farthest from the center of flow. There is little doubt that if a high enough velocity is maintained this condition could be overcome. However, as the pumps slow down and the pressure increases there are instances in which this velocity is never attained.

This type of flow in well cementing is characteristic and may result in the upper portion of the cement column being of poor quality. Trouble can be avoided by running enough cement so the point of hydrostatic balance between the columns inside and outside the casing will be above the top prospective producing zone. By doing so it will not only be possible to maintain high velocities (and consequently a high Reynolds number) above the upper producing zone, but also to displace the contaminated portion of the cement in the annulus far enough up the hole that it will be of no consequence.

It can be seen, then, that best results in casing cementing can be obtained by running enough cement to overcome top contamination and by doing everything possible to increase the Reynolds number. Increasing the density and reducing the viscosity of the fluids pumped result in increasing the Reynolds number. Unfortunately, the viscosity and density of the fluids used in well cementing have their values determined by well conditions rather than by choice. Increase in the density of cement slurries above a certain point results in an increased viscosity that is out of proportion to the increase in density. The dimension factor in the Reynolds relationship has to do with the size of the hole and casing, which are determined by economic considerations. It should be noted, however, that increase in hole diameter with respect to pipe diameter results in an increase in the Reynolds number. A larger measure of control may be exercised on the velocity factor than on any of the other variables in the equation. Any increase in velocity, whether due to movement of the casing or added pump power, will not only increase the Reynolds number by direct application in the equation but also bring about an increase due to the reduction in viscosity accomplished by breaking the thixotropic gels in the drilling mud and the cement slurry.

Mud cake, if left on the wall of the hole, would result in channeling. During the last few years, work has been done by various companies in an attempt to find something that would remove mud cake from the wall of the hole. This work was based on the assumption that mud cake left on the wall of the hole was the cause of poor casing cementations. This, if true, would mean that all wells having comparable mud conditions would have comparable cementing failures. It is not difficult to find cases in which this is not true. This leads to the belief that mud cake is not always the cause of cement failures.

Factual data on wells in other localities support this belief. In wells in some fields mud cakes have been formed on the wall of the hole so thick that a 7-3/4-in. packer could not be run in a 9-7/8-in. hole without difficulty, yet casing cemented in these holes showed characteristics of a perfect cement job. This fact has been established by subsequent acidizing operations in which zones were treated individually at high pressure with penetrating acid through perforations and with a packer set between the perforated zones. The distance between zones was usually more than 10 ft., but many jobs were done in which it was less than 10 ft. and in one case the distance was only 5 ft. No cement failure occurred although a pressure of 1200 lb. per sq. in. was maintained for more than two hours.

All cementing problems cannot be compared with those of hard rock areas; however, the problem of mud cake removal is comparable. The same cementing methods are used in each area; therefore, the same forces must be active in removing the mud cake. This leads to the conclusion that mud cake is removed satisfactorily by normal cementing methods and so is not the cause of cementation failures. In some cable tool wells, when there is no mud cake on the wall of the hole, it is necessary to pump mud ahead of the cement to prevent dehydration of the cement slurry against the formation. This indicates that in many, if not all, cases mud cake is essential to cementing although it may have to be reduced to a minimum thickness if best results are to be obtained.

[1] A thixotropic gel is one that can be changed to a fluid by agitation.

Channeling can be eliminated by maintaining proper fluid velocities if sufficient cement is run to displace the contaminated material at the head of the cement column. Mud cake is satisfactorily removed by normal cementing methods and, therefore, is not the cause of cementation failures. As mud cake is removed by normal methods, there is no necessity for mechanical or chemical devices to aid in its removal.

Squeeze Cementing

Squeeze cementing may be defined as any process in which cement slurry is forced either into or against formations in a well. In any cementing job the cement slurry is more or less "squeezed" against the formations by hydrostatic or other pressure, which may become great enough to cause the slurry to enter some permeable channel in the formation. In view of this reference to squeezing it is necessary to limit the definition of squeeze cementing to cementing work done after the regular casing cementation. The data herein presented are further limited to apply particularly to squeeze cementing work done through perforations, although some of the principles are applicable to open hole conditions.

Theoretical considerations. In squeeze cementing, the minimum pressure that can be used is the pressure that will make it possible to force the cement slurry through the perforations. The pressure attained in doing this may be regarded as indicating what happened to the slurry after it passed through the performations.

Cement slurry, before the initial set, may be thought of as a finely ground inert material suspended in water. All excess water can be driven from the slurry by squeezing the slurry against a permeable formation at a greater pressure than that found in the permeable formation. Dehydration of the cement slurry in this manner actually takes place in squeeze cementing and results in thickening the slurry to an extent that it is no longer pumpable. The rate of dehydration is a function of time, the differential pressure between the fluid in the formation and the water phase of the cement slurry, and the permeability of the formation—due allowances being made for surface tension and fluid content. Thus, if sufficient data were available, the amount of dehydration as well as the thickness of the filter cake of cement could be determined. On most jobs, the differential pressure and permeability can be determined with adequate accuracy. The time factor, however, is more difficult to determine because so many variables are involved.

If the time factor is considered as the length of time a unit volume of cement is in a position to lose water into the permeable formation, it must be inversely proportional to the velocity at which this unit of volume passes a unit of area on the permeable formation. It must also be proportional to the friction involved in permeability of the formation and the constitution of the cement. Stated more simply: If a cement slurry is pumped into or by a permeable formation, dehydration will take place at a rate determined by the differential pressure, the exposed area, the permeability, and the velocity.

Application of these theoretical considerations to well problems leads to the conclusion that when a high pressure is reached with a small volume of cement, the slurry has been squeezed directly against the face of a sand or other permeable formation in which the channels of permeability are small enough to exclude cement particles, and that the slurry had not migrated appreciably up or down the hole. No possible gain can come from this type of job unless water or gas in the formation being squeezed is shut off, or if the formation is being plugged. The succes of this type of job depends on the location of the subsequent perforations, as the cement can only destroy the vertical permeability in an area immediately adjacent to the well bore. If, however, fluid from this sand were migrating up or down the hole to other zones, the job would probably be successful.

If a larger volume of cement is pumped from the perforations at a more or less constant increase in pressure, it may be assumed that the rate of dehydration is slow due to one of several things: (1) the pressure differential may not be great enough to overcome the friction; (2) the velocity in the vicinity of the permeable formation may be too great to permit more than a partial dehydration, resulting only in a gradual thickening of the slurry; (3) the area exposed may be of such low permeability that a considerable length of time is required for the dehydration. In wells

Fig. 1

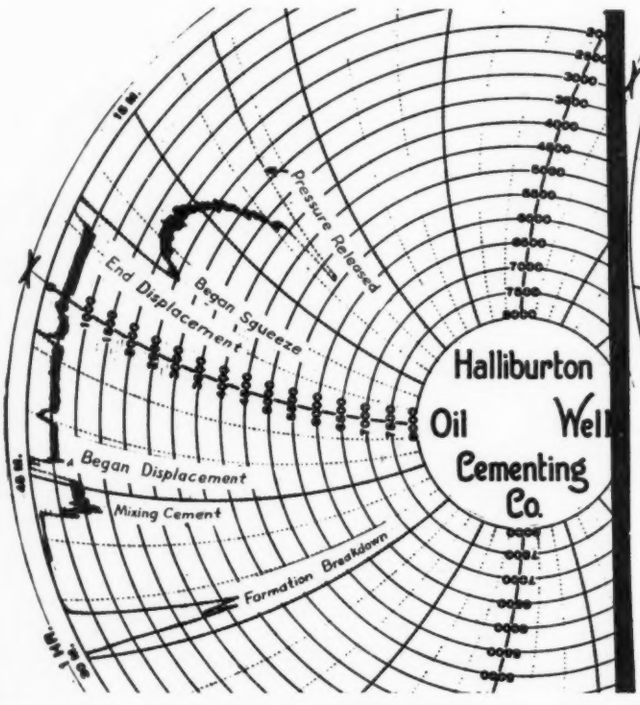
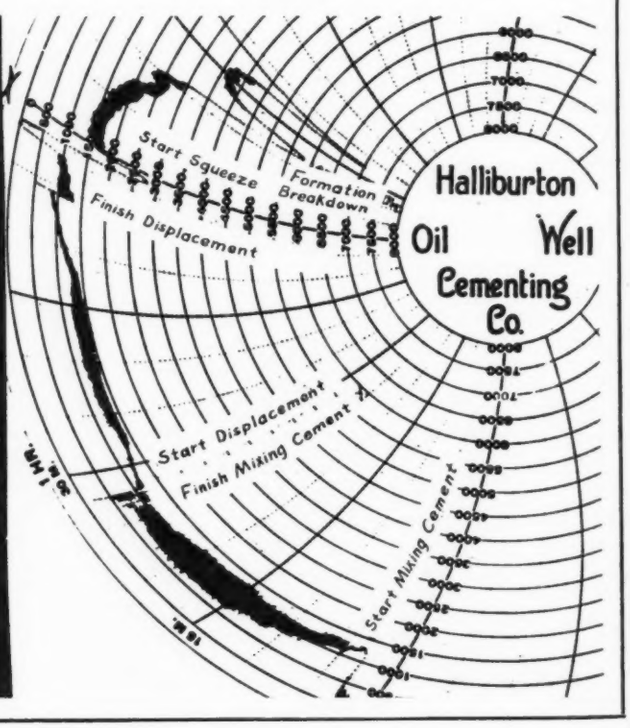
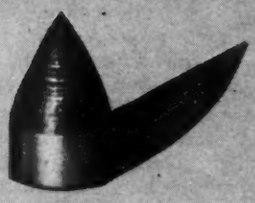


Fig. 2



These Three Factors-



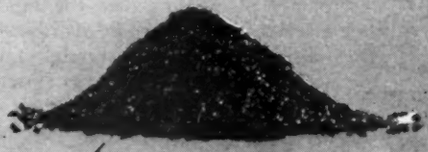
✓ Bullets
FOR EVERY APPLICATION

The Ogival-Point of the Lane-Wells steel flow gun perforator bullet provides a thicker extreme point of greatly increased strength. No chips break off the point to deflect the course of the bullet or affect penetration. The result is deeper penetration, better channeling, greater drainage area and improved hole characteristics.

✓ Chambers
PROPERLY DESIGNED

The chambers of the Lane-Wells gun perforator are properly designed and placed directly behind the bullet to allow the power of the ignited powder to apply its pressure most effectively to the bullet while traveling down the barrel. The combustion chamber is completely closed except for the opening of the barrel bore, so that no powder gas escapes which does not do its work in giving velocity to the bullet.

-mean Better Penetration



✓ Powder
AND POWDER DENSITY

The density of the powder used in the Lane-Wells Gun Perforator is carefully controlled. The powder in Lane-Wells Gun Perforator gives the maximum velocity to the bullet to achieve greater penetrating power.

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that have produced large amounts of fluid and formation material, and in shallow formations in some areas, the pressure differential may not be great enough to overcome the friction due to volume replacement requirements. As the cement starts out of the perforations the velocity in the vicinity of the permeable formation may be too great to permit more than a partial dehydration, but as more cement is pumped into the formation the area exposed to the slurry is increased and small amounts of water may be lost at many points. This dehydration increases the viscosity, which results in a decrease in velocity, which in turn increases the time factor, resulting in more dehydration at the face of the permeable formation. This is the most common result in squeeze cementing. Somewhere during this process, the slurry loses so much water that it is no longer pumpable.

If large volumes of cement can be pumped into the formation at no increase in pressure, it is logical to assume that no dehydration is taking place. The reason may be any one of those already mentioned, which one may be difficult to say. Of the three reasons enumerated the third one is the most common. The remedy in any case is to run small batches of cement at long enough intervals to permit each batch to set before another is run. Frequently, this type of formation will test dry on a drillstem test, when a relatively low pump pressure will force fluid into it.

Pressure due to the weight of the overburden is roughly 1 lb. per ft. of depth, and is the figure used in determining necessary squeeze pressure. Three pieces of useful information can be derived from this pressure-depth relationship: (1) The initial break-down pressure (pump pressure plus hydrostatic pressure of the mud column) should be roughly equal, numerically, to the depth in feet; (2) when the initial breakdown pressure is less than this the fluid pumped must be following lines of permeability in which the fluid is under less than overburden pressure; (3) maximum pressures, if greatly in excess of the overburden pressure, must lift the overburden unless a dam has been formed (by dehydrated cement or other material) of sufficient strength to withstand the pressure necessary to keep the fluid slurry separated from lines of weakness in the formation.

What is the theoretical pressure necessary to accomplish a satisfactory squeeze cementing job? Obviously, so long as the formation is "taking" cement at a pressure less than that necessary to raise the overburden, the channels of permeability have not been closed, and when more pressure than this is necessary to pump the cement into the formation, new channels are being created. If the pumping pressure greatly exceeds that of the overburden the cement is being lost into the formation. If, however, the job follows either pressure-depth relationship (1) or (2), a point will be reached at which the slurry will no longer move. When this point is reached, further application of pressure can do no good and may be detrimental.

The pressure recording shown in Fig. 1 is of a typical squeeze job. Note that after a pressure of 4000 lb. per sq. in. was reached only a very small volume of fluid was pumped to raise the pressure to the maximum pressure of 5500 lb. per sq. in. In this particular case there was practically no movement of fluid through the perforations in the casing after a pressure of 4000 lb. per sq. in. was reached. Had the maximum pressure been carried higher, new channels of permeability might have been created as indicated in Fig. 2. In this case the formation was fractured and new channels of permeability created that almost cause the entire job to be a failure, whereas it would have been entirely successful had the pumps been stopped at a pressure just greater than 3000 lb. per sq. in.

As the rate of dehydration is dependent on so many factors, the exact pressure necessary is difficult to determine. Experiments conducted in Halliburton Oil Well Cementing Company laboratories, have shown that a differential pressure of 1500 lb. per sq. in. permits satisfactory dehydration of cement slurries against permeable formation. Consequently, if the shut-in bottom hole formation pressure is 3000 lb. per sq. in., the corresponding pressure necessary to dehydrate the cement slurry would be 3000 lb. per sq. in. plug 1500, or 4500 lb. per sq. in.* The pump pressure necessary at this depth to raise the overburden would be 3200 lb. per sq. in. if the hole were full of water.* Actually it is found that factors of friction and velocity are so great that the rate of dehydration is reduced appreciably. In an attempt to correct this, more pressure is applied, which increases the rate of dehydration and results in the type of job referred to in Fig. 2.

Effect of squeeze cementing on various formations. Years of experience in squeeze cementing have shown that the possibility of permanently damaging oil or gas sands by squeeze cementing is extremely remote. In the Texas and Louisiana Gulf Coast areas, it is common practice to squeeze cement directly into perforations opposite oil sands. To date, the writer has heard of no cases in which sands have been permanently plugged with cement in deep high pressure wells. Two probable reasons for this are: first, cement will not set in the presence of oil, and second, oil sands are usually so fine-grained that the space between the sand grains is too small to permit particles of cement to enter. The interstices between sand grains will exclude all materials whose average diameter is greater than one-sixth the average diameter of the sand grain. Accordingly, any sand that will pass a 20-mesh screen will effectively exclude cement.

Sometimes the thickness of cement formed behind the casing in unconsolidated sands may be so great that gun perforations do not open channels into the formation. In cases of this kind good results have been obtained by forcing fluid through the perforations with pump pressure. Although the fluid opens a channel through the cement into the formation, it has little effect on the productivity of the formation. As a matter of fact, there have been cases in which prolonged pumping of water into a formation has increased its productivity. There is little question, however, that heavy drilling mud is likely to form dense mud cakes on the face of the formation that can be removed only with great difficulty. Undoubtedly the best solution to this problem is to treat the formation with mud acid.

Experience has shown that shale is the cause of most cementing difficulties. This fact is borne out by the almost 100 per cent success of cementations in localities when there is no shale in the productive formation. Little difficulty is encountered in cementing sand sections. It would therefore seem foolish to try to accomplish squeeze jobs in thick sections of shale unless absolutely necessary. As cement does not penetrate sand sections, cement in large volume pumped through perforations opposite such sections is believed to penetrate planes of weakness at the sand-shale contact. As the purpose of these squeeze jobs is to isolate a certain sand, the squeeze points should be as close to the sand as possible. This practice should not injure the sand and will make it possible to obtain a more satisfactory squeeze job with less cement.

Squeeze cementing methods. The method presented here is that most commonly used to overcome difficult cementing conditions. The amount of cement to be run on any job can only be determined by experience in the particular field in question. This amount of cement should be mixed and displaced into the formation until the cement will no longer move at a predetermined maximum pump pressure. If this pressure is not reached with the first batch of cement, the perforations should be cleared by displacement and subsequent batches of cement run until the desired pressure is attained. The cement may be considered to have stopped moving

*No allowance is made for friction.

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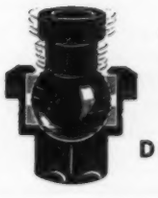


when the pumps can be shut down and the pressure does not decline. After having thus accomplished a positive dehydration of the cement slurry, the cement below the squeeze tool should be allowed to remain in the hole until it has hardened.

Setting time of cement on squeeze jobs. The time required for any given cement to set depends on the temperature, pressure, and water-cement ratio. Temperature and pressure increase with depth and the water-cement ratio decreases if dehydration takes place in squeezing. This increase in temperature and pressure and the decrease in water-cement ratio tend to accelerate the setting of the cement. On a normal deep squeeze cementing job, therefore, two hours is an adequate time to wait between batches. When a squeeze job has been completed, as described, best results will be obtained by allowing the cement to set at least 24 hours. On extremely bad jobs, 48 hours is not too long to wait.

Testing squeeze jobs. As squeeze cementing is done with the idea of plugging off something, the best test of a squeeze job is to see whether the perforations squeezed will produce anything. This can be done either by swabbing or by a drillstem test. If squeeze jobs are conducted in the manner described, the cement left in the casing will have to be drilled out before a test of any kind can be made. The greatest pressure the job will be required to hold from the inside of the casing is the maximum pressure expected when the well is on production; there is no reason, therefore, to run the pressure beyond this maximum when a pressure test is made. After drilling out the cement opposite the perforations, enough pressure to make this test can usually be applied without use of squeeze packers. Many formations that can be easily pumped into will produce no fluid. Also, there are many formations that cannot be pumped into that will produce much fluid. Consequently, the only adequate test for a squeeze job is to test the perforations for production either by swabbing or by a drill stem test. This method of testing will result in eliminating many squeeze jobs, and in lowering the cost of well completion.

Uses of squeeze cementing. It has been common practice to use squeeze cementing only as a corrective measure when undesirable fluids were produced on production tests. Many operators now have adopted the practice of squeeze cementing immediately above and below productive zones prior to production tests. This practice has proved to be more economical than the old method, because good squeeze jobs are thus more easily accomplished at the desired point, resulting in a saving of time in cementing and testing work. This method is particularly advantageous in areas of known or expected water or gas trouble.

The difficulties encountered in squeeze cementing increase directly with the extent of perforations and the number of zones perforated. So far as the number of zones perforated is concerned, the chief difficulty is in finding the source of water or gas. The hazard in squeeze cementing to exclude these fluids is increased by other zones being open. The chances of a satisfactory squeeze job decrease as the interval (distance) between perforations increases. In other words, it is much easier to obtain good results in squeezing a 5-ft. interval than a 45-ft. interval. This is particularly true when the perforations extend the entire thickness of the sand for then it is impossible to control the placement of the cement.

Summary and Conclusions

In multiple sand wells the most common cause of casing cementation failure is due to too little cement being run to cover all producing zones properly. This problem can be overcome by the use of data from caliper and temperature surveys. Channeling of cement slurries can be eliminated by displacing the cement into the annulus at a velocity high enough to maintain turbulent flow conditions. By running enough excess cement to bring the point of hydrostatic balance of the cement columns inside and outside the casing to a level above the top producing zone, top contamination difficulties can be overcome. Even though cement is placed in such a manner as to eliminate channeling, some formations may not be properly segregated. The characteristics of some formations may be such that they cannot be overcome by normal cementing methods. Research work is being done on this problem. To date the most economical and satisfactory method yet found is that of squeeze cementing through perforations after the casing cementation.

Squeeze cementing failures are invariably the result of placing insufficient cement in the well and in such a way that it will not set in the desired place. This problem can be largely overcome by squeezing at the most logical points above and below or in the producing zone. Control in placement of slurry squeezed through perforations is facilitated by reducing the number and extent of perforations to a minimum and by doing all squeeze cementing work prior to perforating the producing zone for production tests. Cement slurries thus properly placed must be given a chance to set. To insure that the set will not be disturbed by agitation, etc., it is best to perform the squeeze job so that the cement is caused to set by dehydration. Such dehydration can be recognized by observing surface pump pressure.

Much knowledge has been accumulated from past experience concerning the reaction of various formations to squeeze cementing. Experience in the field has been substantiated by tests in the laboratory, but the final word has by no means been written. Research is being continued in the field and in the laboratory with the idea in mind that each improvement in technique and each reduction in cost are steps toward the ultimate perfection in oil well cementing service.

—— ☆ ☆ ☆ ——

Now You See It—Now You Don't

The United States has a sufficient oil supply for at least several generations unless the political climate of the future chills the initiative and courage which Americans have always demonstrated in the discovery and development of oil. . . . Millions of acres of land regarded as favorable from the geological standpoint for the accumulation of oil are as yet untested.

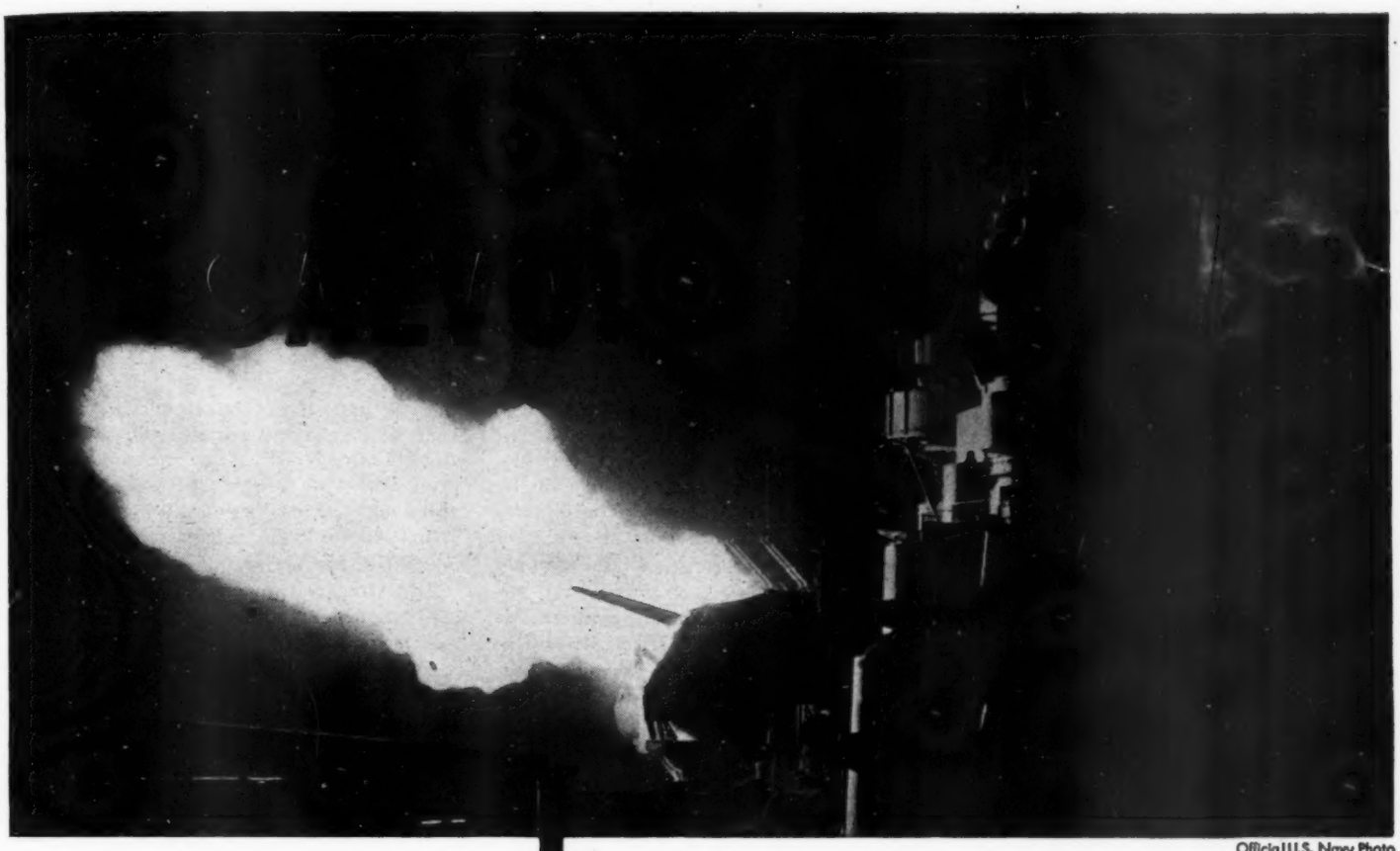
—Annual Report, 1943, Sun Oil Company.

In view of the fact that much of our oil in future years must come from foreign fields, the industry will need the cooperation and protection of our government. Domestic reserves have been so thoroughly explored that it is not difficult to see the dangerous position in which the country is likely to find itself in ten years or less.

—Monthly Business Review, The Guaranty Trust Company.

He (Walter Lippman, the columnist) points out that since 1933 private American interests have acquired about 40 per cent of the reserves of the Persian Gulf region and that we have a 70 per cent interest in the Caribbean area. Senator Brewster interprets this to mean we have 20 billion barrels of reserves at home and 20 billion abroad, not a bad record in world competition; the best record in the world, in fact.

—Editorial, The Tulsa Tribune.



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It's putting the first salvo 'broad on target' that wins! Second-best salvos, like second-best poker hands, don't count—any more than second-rate oil-well cementing jobs. That's why oil men make certain the first time—by selecting cement specially designed to fit the job in hand. Four great Lone Star Cements cover the entire range of oil-field service . . . let job conditions decide which cement to use:

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'STARCOR'* for deep wells, high temperatures and pressures . . . highly resistant to action of sulphate waters;

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Heat Absorption in Direct-Fired Tubular Oil Heaters

PETROLEUM ENGINEER Exclusive Feature

PART 2 (Concluded)

by R. G. Lovell

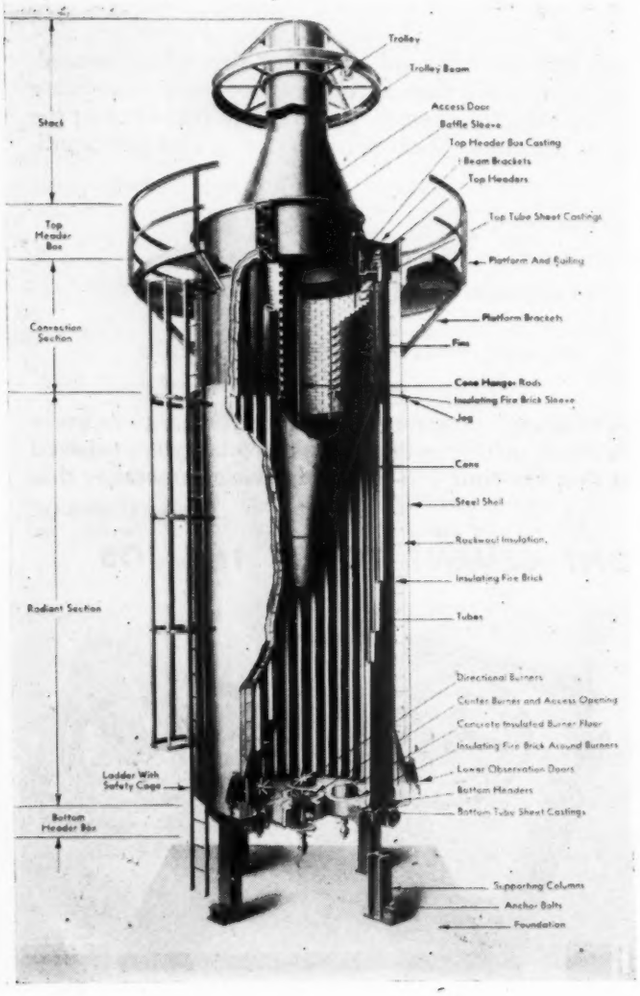
Development Engineer, Hancock Oil Company of California

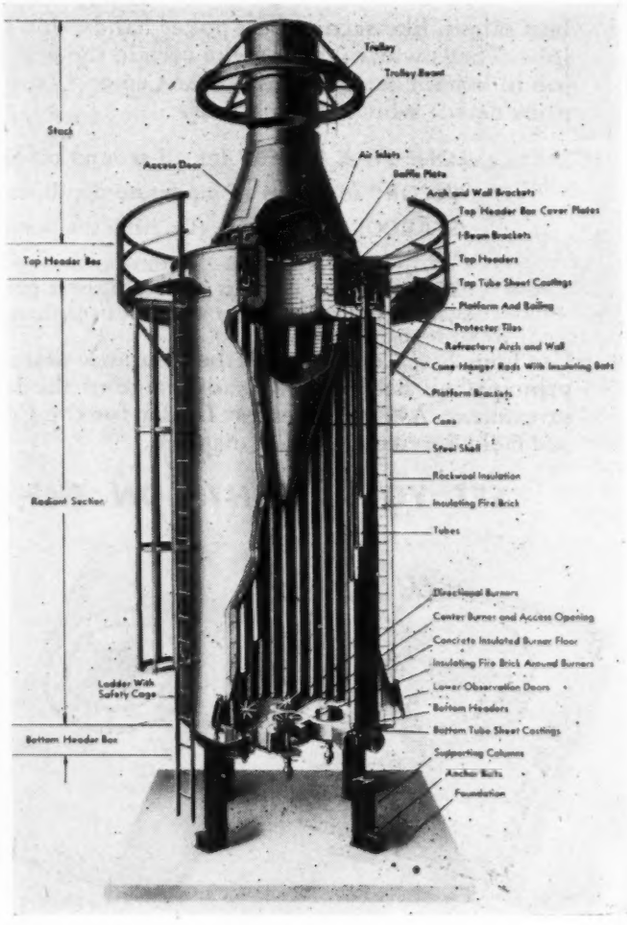
HEATER manufacturers have not been oblivious to the changed trends in refinery processing and have worked out designs for meeting selective requirements, some of which have come into widespread use. It may be that the design was spurred by the vital necessity for conserving critical materials and manpower as much as by the altered refining demands, but it now appears that the individual and cell types of heater can stand on their own merits entirely apart from the question of conserving materials.

Fig. 5 shows one type of individual heater that has several novel features and is in general and increasing use. The phantom view makes the general idea clear and the reader will profit more by making an analysis from the illustration than from an effort of any other person to interpret it. We shall simply point out the features that have impressed us as fulfilling the requirements set up earlier in this article. It will be obvious that all tubes in the radiant section are equidistant from the flame burst. This has the definite advantage of uniform distribution of the radiant heat over the absorption area.

The first impression from a casual look at Figs. 5 and 6 is that the previously considered sound principle of counterflow of furnace gases and oil has been violated and that oil is being alternately heated in the radiant section and cooled in the convection section. The notion has its foundation in the fact that we have been accustomed for years to thinking along one line only in solving the problem of proper division between heat absorption by radiance and by convection. We have fallen into the habit of overemphasizing temperature difference—greatest, least, and mean—

Fig. 5. (Left) Vertical cylindrical heater, radiant-convection type
Fig. 6 (Below) All-radiant type vertical cylindrical heater





There is No Substitute for Experience

ONLY by actually building a model ship can a boy get the experience and knowledge of the old sailor—to appreciate the qualities and performance of good materials. Similarly, only by the same method—*actual use*—can you learn to recognize the qualities of Hycar synthetic rubbers—the very qualities you want in resilient materials.

Hycar is a versatile synthetic rubber—completely resistant to petroleum products of all kinds. It has an operating range from −65° to +250° F. and an abrasion resistance 50% greater than natural rubber. Unlike many other resilient materials, Hycar has a minimum tendency to cold flow after taking the initial deformation, even at elevated temperatures. And it can be tailored to fit the job because oil-swell can be held to ±1%, or even to zero.

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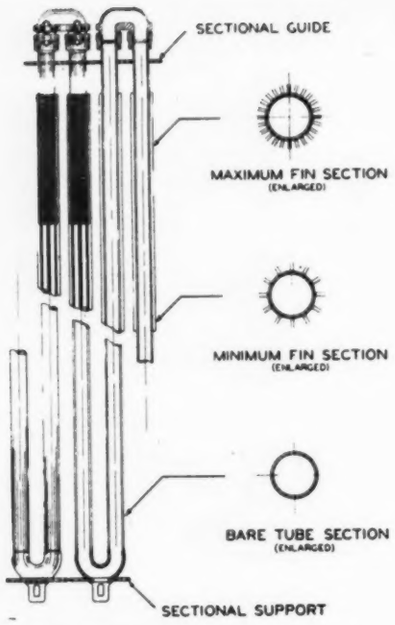

Fig. 7. Fin tube and header assembly of Iso-flow furnace

in our consideration and have been more concerned than was warranted over high stack temperatures. Perhaps this latter worry arose from consciousness that there was little we could do about reducing these high temperatures without use of costly auxiliary apparatus.

Following the course of the oil in the heater illustrated, it will be observed in Fig. 5 that the entrance is at the bottom with upward flow. When the oil in a tube has reached the end of both direct and secondary radiant zones —the top of cone—it enters a section of tube length the heating surface of which has been increased by use of fins. As heat is abstracted from the gases it becomes necessary to add to the fin area to attain proper rate of heat transfer at the lowered gas temperatures. The relative fin areas are a part of the calculation that includes quantity of flow, inlet and outlet temperatures, etc. Further control of heat absorption by sections can be obtained by manipulation of the directional burners. There seems to be no reason why the coil could not be easily divided into separate sections for multi-duty operation particularly in light of the advantages offered by the directional burners. The manifolding would not be difficult and, if proper valves are used, would function with complete satisfaction.

The manufacturer of the unit illustrated would appear, to the writer, to be justified in his claims for accessibility and ease with which tube replacement could be effected but the primary advantages would seem to lie in flexibility of control and adaptability to widely varying process demands. Much of the credit for these characteristics must be given to the better draft condition. It should be noted that the cone not only creates a secondary radiant zone but in the radiant-convection type of furnace serves to increase the furnace gas velocity to the point required for efficient heat transfer by convection.

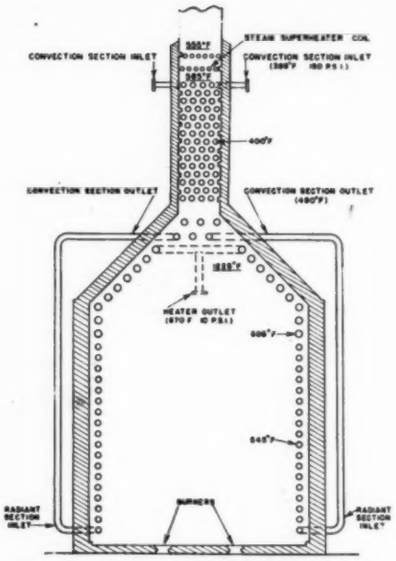

Fig. 8. Cross-sectional view of rectangular furnace up-draft heater

All-Radiant Type

The all-radiant type heater shown in Fig. 6 is of the same general idea as the radiant-convection model but has no facilities for transferring heat from furnace gases to oil by convection. This type is probably not so efficient in use of fuel as the radiant-convection design and the stack temperatures could be expected to be considerably higher. It would, however, fit in well with several of the heating jobs in catalytic cracking and the high stack temperature could be used to advantage for boiler feed water heat, steam superheaters, or similar duties. The writer ventures the prediction, in this connection, that the refinery of the future will accept these high stack temperatures but, instead of looking upon them as a necessary evil, will turn them to good account in developing refinery utilities such as steam and electric power and to such a degree that, together with the heat of catalyst regeneration, little capital or revenue will be used in providing these facilities independently. In fact, it is entirely to be expected that no fuel will be used for preliminary crude oil heating or for heating mediums for reboiling in the precise fractionation that is to be demanded of us. In the all-radiant type heater also appears a relatively easy and inexpensive way of obtaining some preheat for combustion air with a minimum of auxiliary apparatus.

Up-Draft Heater

Fig. 8 shows another type of the unit idea with up-draft of furnace gases. In

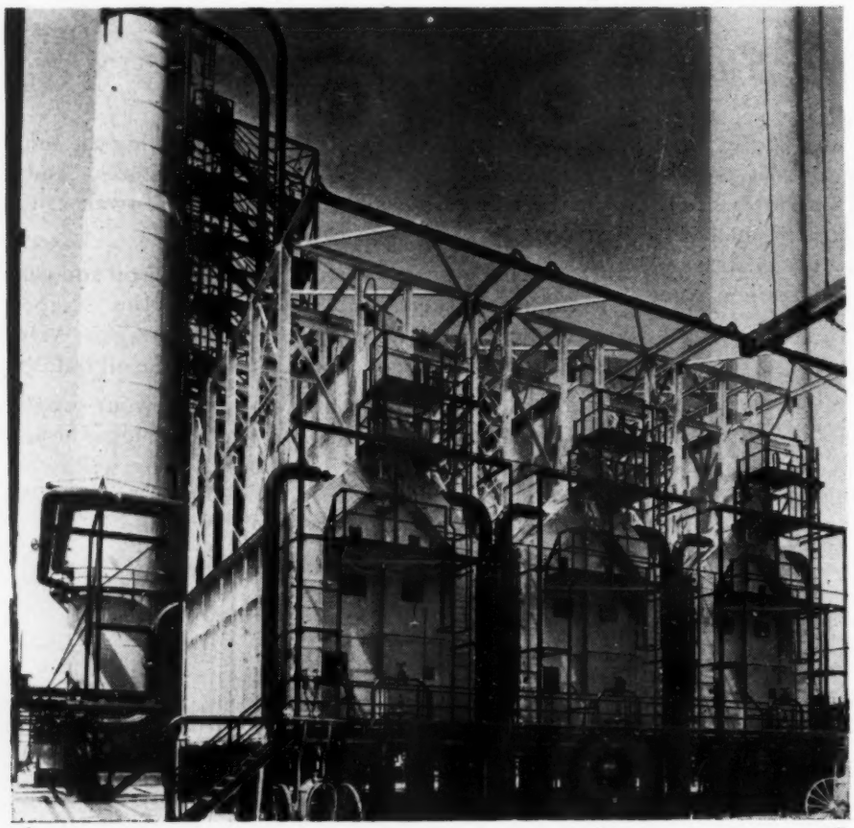

Fig. 9. Battery of three cell type heaters connected through plenum chamber to common stack

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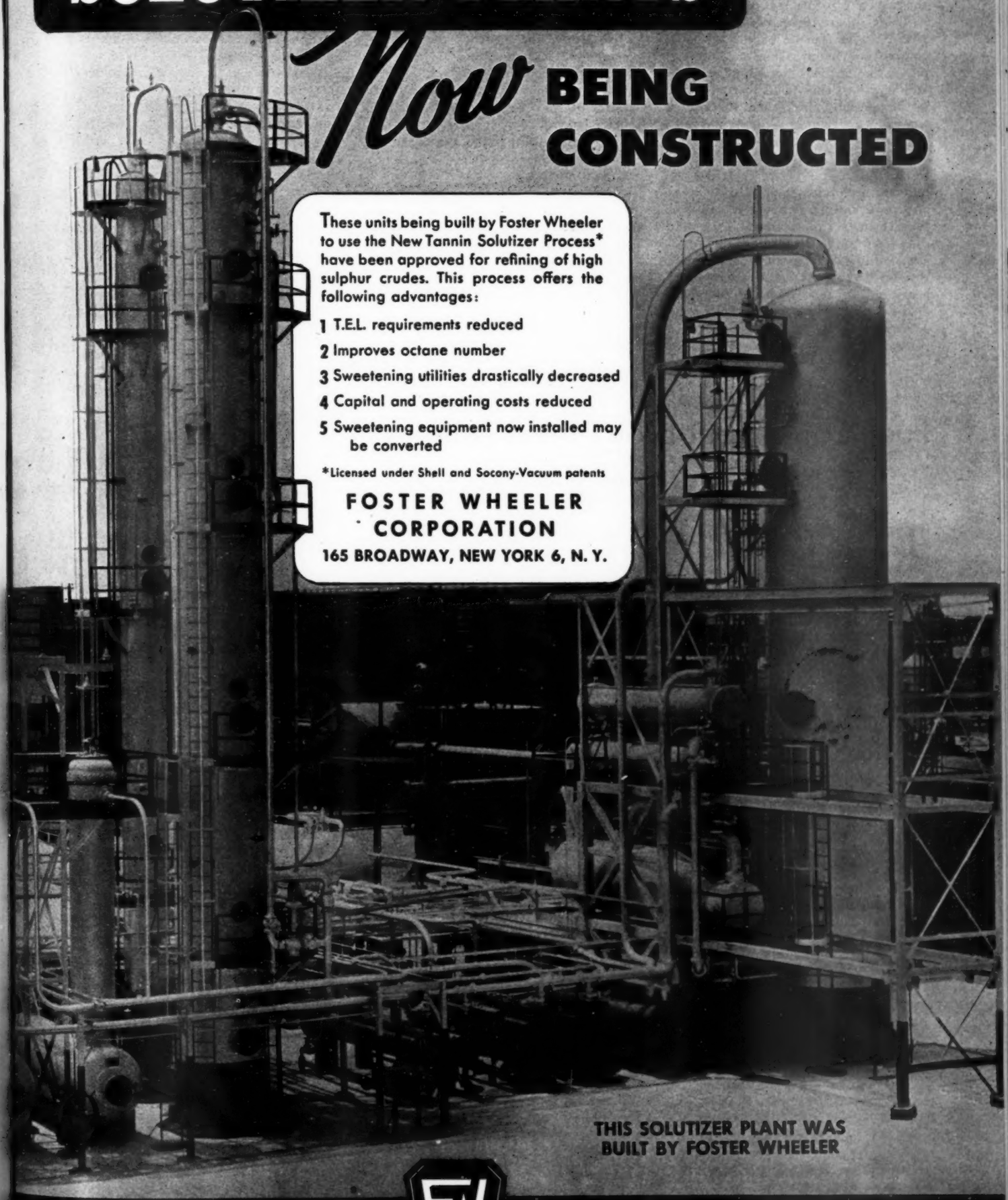

These units being built by Foster Wheeler to use the New Tannin Solutizer Process* have been approved for refining of high sulphur crudes. This process offers the following advantages:

1 T.E.L. requirements reduced

2 Improves octane number

3 Sweetening utilities drastically decreased

4 Capital and operating costs reduced

5 Sweetening equipment now installed may be converted

*Licensed under Shell and Socony-Vacuum patents

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THIS SOLUTIZER PLANT WAS BUILT BY FOSTER WHEELER

FOSTER FW WHEELER

this design the rectangular shape of firebox has been preserved along with the manifest advantages of up-draft.

There appear to be several points of advantage in the use of this shape of combustion chamber. The most obvious one is the uniform heat input over the full length of tube. This feature would be of special value when the charge stocks are particularly sensitive to temperature, such as in viscosity breaking, distillation of volatile crudes, and in a re-run operation wherein there is a top temperature limit not to be exceeded at any point in the heating cycle. The manufacturer of the unit illustrated calls attention to the liberal ratio of furnace volume to B.t.u. of heat liberated, thus reducing the required input of heat to oil per square foot of tube area, as the larger chamber connotes greater perimeter, thus affording more tube placement space. It is also represented that this greater combustion chamber area is obtained while still limiting the height of the radiant section to from 10 to 15 ft. This can, of course, be expected to reduce the tendency of the furnace gases to channel and also to provide greater floor area in which to place more small burners. All these factors contribute to better combustion and to better control of heat distribution between radiant and convection sections. The improvement in barometric limitation is obvious.

In Fig. 9 is shown a battery of these cell type heaters designed for a topping operation and with throughput capacity of 25,000 bbl. per day. In the final design of this battery, each heater carries an equal portion of the oil and the flow through each heater is divided into two streams, giving a total of six parallel flows for the installation. This, obviously, adds to flexibility of operation, as a tube failure or leaky header in one of the three heaters does not necessitate a complete shutdown. Operation could proceed at two-thirds capacity until repairs could be made. Such an arrangement of flow would be of material advantage if the heater is performing a multiple operation, as tube sizes could be altered in different sections to accommodate varying degrees of vaporization. These particular heaters, under test, are said to have developed the temperature and pressure conditions shown in Fig. 8 while handling 26,000 bbl. per day of volatile crude. The heat liberation was approximately 108,000,000 B.t.u. per hr. with fuel gas of a net heating value of 1383 B.t.u. per cu. ft. Stock gas analyses showed 18 per cent excess air and the overall thermal efficiency was 84 per cent based on the net heating value of the fuel.

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Fuel Consumption of Diesel Engines

P 422.344.4

by W. F. Schaphorst

"IN the event that we should install a diesel engine in our plant how much fuel would it consume at fractional loads as well as at full load?" That question is often asked by officials who are considering the use of a diesel for power purposes.

This writer has made an effort to answer the question definitely and fully. He has gathered data on fuel consumption by modern diesels of numerous sizes and has prepared the following table. This tells at a glance what good diesels are doing today, the horsepower varying from the smallest sizes up to and including 3000 hp. The table applies to full load conditions.

Hp. of diesel	*Lb. of fuel used per hp-hr.*
50—60	0.45 to 0.44
60—70	0.44 to 0.43
70—110	0.43 to 0.42
110—260	0.42 to 0.41
260—500	0.41 to 0.40
500—1000	0.40 to 0.392
1000—2000	0.392 to 0.391
2000—3000	0.391 to 0.39
3000—and up	Slightly less than 0.39

For instance, if your requirements are very small—50 hp. or even less—you can figure on a fuel consumption of 0.45 lb. per hp-hr. with a modern engine. If you need a 100-hp. diesel the consumption will be about 0.42 lb. per hp-hr. The table shows that with increase in engine size the fuel consumption improves rapidly from the smallest sizes to 260 hp. From 260 to 1000 hp. the improvement is less rapid, and from 1000 to 3000 hp. the improvement is very slight, being practically 0.39 lb. per hp-hr. for all sizes in that range as well as for larger sizes.

Should you want to determine the efficiency of any size, with any fuel, multiply the B.t.u. value of the fuel per lb. by the number of lb. per hp-hr. and divide the product into 2546.

As an example, if the fuel contains 20,000 B.t.u. per lb. and you will require a 500-hp. engine, the table shows that you must multiply 20,000 by 0.40, which gives 8000 as the product. Now divide 2546 by 8000 and it will be found that the engine will have an efficiency of 31.8 per cent, which is a high efficiency. It means that 31.8 per cent of the heat contained in the fuel will be converted into work. Even at 0.45 lb. of fuel per hp-hr., other conditions being the same, the efficiency will be 28.3 per cent, which is a high efficiency for any engine.

The above figures relate solely to diesels that are carrying 100 per cent load, which means that conditions are best for minimum fuel consumption. However, as diesel engines are commonly operated at less than full load, it is also important that prospective users should know what the fuel consumption will be at such loads.

Under average conditions, using the good diesels mentioned above, the writer offers the following figures as being applicable.

Percent of load	*Multiply the figures in the above table by*
100 to 85	1.000
85 to 70	1.010
70 to 62	1.035
62 to 56	1.060
56 to 52	1.085
52 to 48	1.110
48 to 46	1.136
46 to 44	1.160
44 to 42	1.183
42 to 40	1.210
40 to 38	1.232
38 to 36	1.260
35	1.306
34	1.327
33	1.348
32	1.370
31	1.392
30	1.415
29	1.438
28	1.462
27	1.486
26	1.511
25	1.536

For example, if you should be contemplating a 100-hp. diesel, and if it is quite possible that the engine will be operating at 25 per cent of full load most of the time, as is not at all uncommon practice, the fuel consumption at that load is obtained by multiplying the 0.42 in the first table by the 1.536 in the second table. As a result we have: $0.42 \times 1.536 = 0.645$.

In other words, the fuel consumption will be approximately 0.645 of a lb. per hp-hr., or, 64.5 lb. per hr. for the engine, as it will be a 100-hp. engine.

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Pipe Line
P 629.

Annual PIPE LINE NUMBER 1944

Increasing Workman Efficiency

☆ Proper use of colors aids efficient operation and reduces accidents and absenteeism

PETROLEUM ENGINEER Exclusive Feature

by W. E. Nestor
Superintendent of Compressor Stations, Arkansas Louisiana Gas Company
As told to
DON ATTAWAY

THE petroleum industry has spent millions of dollars on time and labor saving devices. Most of this expense has been on ways and means of saving equipment, reducing worker fatigue, and improving efficiency, all of which advances the cause of safety.

Modern industry records many cases where mere trifles in operation have turned out to be of tremendous importance. Such an example is the new science of light and paint or, as one prominent paint manufacturer terms the system, "color dynamics." At first thought, it may be hard to believe that the color of a compressor, lathe, drill press, or work shop could have any effect upon a worker's morale or his rate of production, but conclusive proof has been found in case after case of color application whereby seeing has been made easier. One authentic record shows a reduction in the consumption of headache tablets from 1000 to 400 a month, coincident with the improved lighting.

Actually the application of color to working equipment and areas is an ideal solution to the illumination problem and eye fatigue. It is common knowledge that the adverse effects of eye strain are felt in many parts of the body. The eyeball is operated by seven muscles and these muscles get tired just like any other set of muscles. Eyes have a habit of wandering and in many operations the eye roams over much unnecessary space because there is nothing to hold it in one spot.

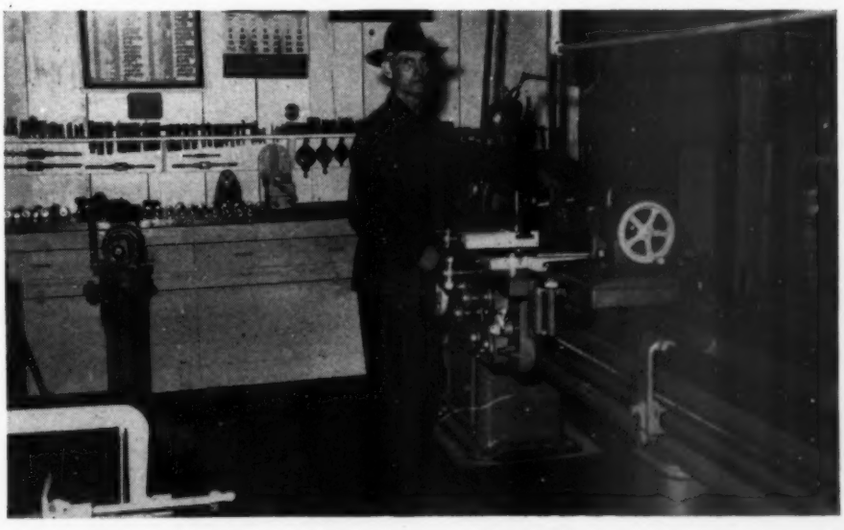
On the other hand, tension wearies the worker's eyes when the color of the material he is working with is similar to the color of his tools or machine. Differentiating between the material and machine is difficult.

Constantly adjusting the eye from one light intensity to another causes fatigue. The same effect occurs in going from a sunlit street into a darkened theater. A worker moving from outdoors to indoors or facing a window or door for alternate operations experiences the same fatigue. Often illusions are created regarding distance and workmen trespass in danger areas or misjudge clearances.

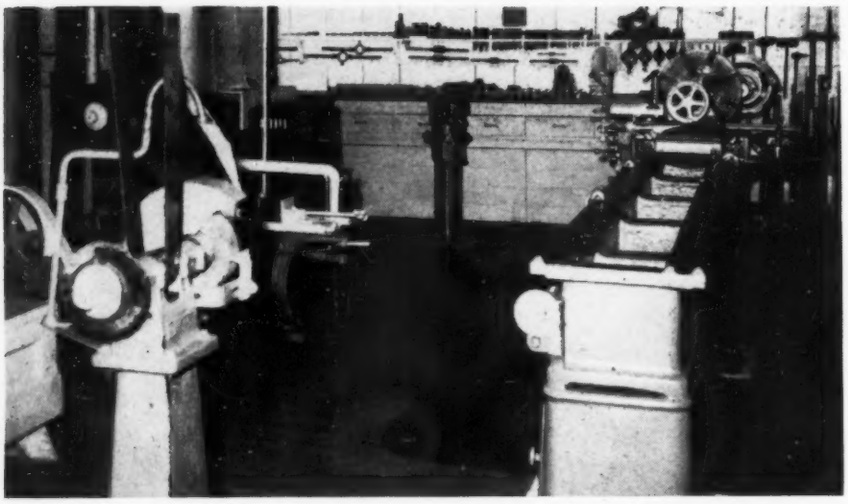
These facts form the basis of the objectives desired in applying color to the problem. These aims are:

1. To promote morale.
2. To improve efficiency.
3. To maintain quality.

Photographs by J. E. Hampson, Arkansas Natural Gas Corp.



Colors at work in the Rogers Station machine shop. Note the sharpness of the machine parts and the clearness of the working area. In the background can be seen the light effect of the wall, the neatness of tool arrangement, and orderliness of work bench



End view of lathe, grinder, and hacksaw. Note well-defined working area in front of lathe with border. Outside line is bright red, working area is black. Machinery is darker green than side wall

4. To reduce absenteeism and accidents.

All these aims were achieved in applying a systematic paint job to the machine shop of the Arkansas Louisiana Gas Company, Rogers Compressor Station near Oil City, Louisiana.

This machine shop is housed in an old frame building formerly used as a warehouse. Due to its location and construction, it was impossible to have windows on but one end and one side of the structure. The interior of the building was very dark and electric lighting was necessary night and day. The walls had been painted white in an effort to improve the condition but despite every method and device used, the highest light meter reading obtainable was three-hundredths of a foot candle per square foot. This was woefully inadequate and actually hazardous.

The solution of the problem was found in the theory of color dynamics.

Starting with the floors, a complete renovation was employed. All aisle surfaces were painted gray and the surface under each piece of machinery was painted black with a brilliant red border on the outer rim nearest the aisle. The wall surfaces on the north and west sides were given a coat of focal green and the south and east walls were painted cream. The machinery proper was given a darker green than the color of the walls. The working surface of each machine was painted cream. All moving parts were coated yellow and switch boxes and electrical attachments were given a treatment of red. The ceiling alone was painted white.

Instantly the application of the color scheme produced results as the light meter readings now showed ten foot candles per square foot. No addition or relocation of lights was required and all electric wiring remained in its original installation.

The gray floors, outlined by black spaces around the machinery, actually widens the alleyways for safe walking and working purposes. The bright red stripe flashes a warning that machinery is being approached. The focal green has an easy, natural effect on the eye and acts as a counter for the darker green of the machine proper, thus reducing working tension.

The cream color on the two walls is a most valuable aid to lighting effects. Moving parts with their intense yellow have a compelling effect in comparison to the working surface cream color, which actually increases vision.

Hazard areas, such as electrical switches and attachments, flash a bright red "keep off" signal.

This assortment of colors definitely has a psychological effect upon a workman. Certain of these colors impart a cheerfulness. The walls provide eye-rest surfaces and induce a sense of restfulness. The green of the machines against the lighter green of the walls seems to make distances recede and creates a spacious and uncrowded working area.

Undoubtedly a desire and sense of good housekeeping was also born with the color scheme, for workmen in this shop now keep it spick, span, and spotless. Every man agrees that he can do more work with less fatigue and that the shop is just as effective and safe at 4:00 p. m. as it is at 9:00 a. m.

Perhaps there are those that will say the idea looks good with everything new and shining but ask what will happen at the end of six months or a year. The answer is that nothing happens if a reasonable maintenance schedule is followed. Some periodic repainting is required but the expense is negligible in comparison to lost time from accidents and absenteeism. In fact, the increased productivity and time saved by the proper distribution of color to produce an effective three-dimensional effect is profit in itself.

Results have been so satisfactory in this installation that plans are now being laid to apply the paint scheme to other machine shops.

Every operator wants his workers to stay on the job, to produce the maximum quantity of material, to have the quality of their work measure up to the highest standards.

Every employee wants to have a clean and safe place to work, to make his working day pleasant and cheerful, to be pleased and contented on the job.

Paint and light make a real contribution toward attaining these objectives.

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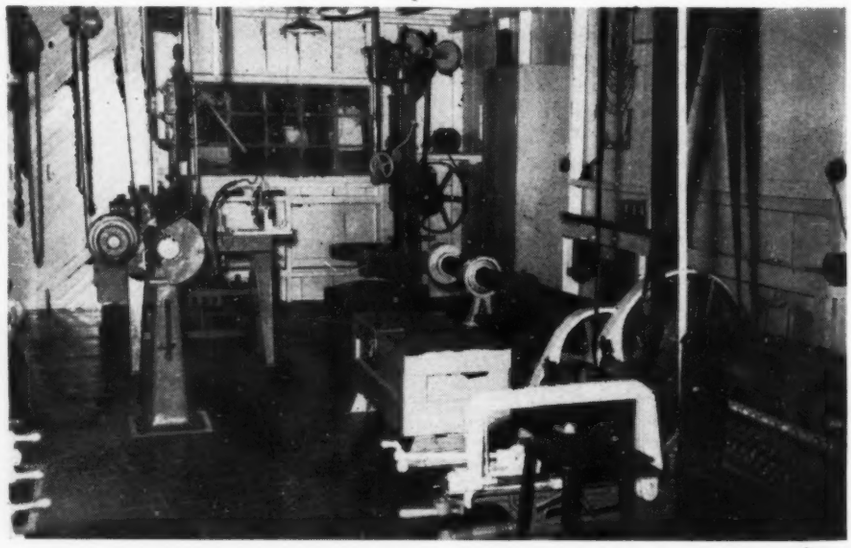
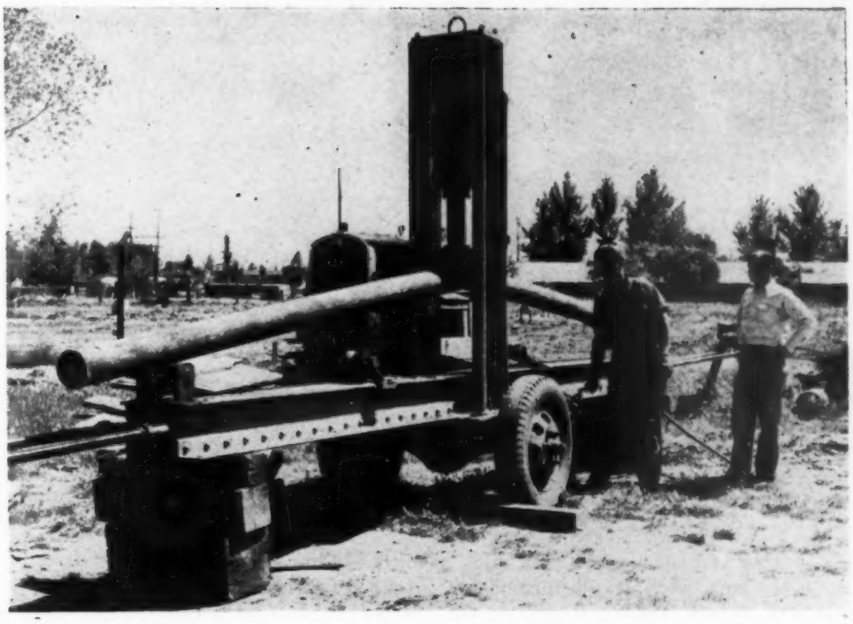


View of grinder, hacksaw, and drill press. The working surfaces that appear to be white are actually yellow. Back wall is cream, wall at right is a soft green. Note pleasing appearance of floor



Straightening pipe for relaying. The joint of pipe, with bad bend, is shown as it was placed in the straightening machine

PETROLEUM ENGINEER Exclusive Feature

Pipe Line Maintenance Important Factor in California

☆ Limited construction of new lines and increased capacities of old make upkeep essential

by Wallace A. Sawdon
Pacific Coast Editor

WITH construction of new pipe lines restricted and with many old lines carrying more oil and gas than ever before, maintenance of lines now in service throughout the state of California has become of great importance. Loss of any oil during this period when requirements for military and civilian use exceed production is naturally more serious than in normal times and involves more than a monetary consideration. Gas to vast war industries, to other industrial plants, and to a greatly increased population must also be supplied without interruption. Breaks and leaks will occur under ordinary conditions but the danger is aggravated when higher pressures must be applied to increase capacity. Preventive, as well as corrective, measures must therefore be taken. Many of the lines in California are rather old and if materials, labor and other facilities were available they could probably be replaced with new pipe at less expense and with greater confidence in future service than by repair operations. Pipe, labor, and transportation are not readily available, however, so reconditioning and the utilization of used pipe has to meet the situation.

Considerable repair and reconditioning of pipe lines has heretofore been done by oil companies and many of these companies have suitable equipment for the performance of this work. The shortage of manpower and transportation units that could be used for pipe line operations, however, has made it impossible for them to do the work in most instances and has thrown the burden on pipe line construction companies. On the other hand, this situation has made it possible for the construction companies to build up more or less permanent crews which, by serving a number of companies, provide facilities for emergency jobs that would be a serious problem for the oil companies, which under normal conditions would take care of the jobs with their own crews. Manpower, of course, is also a problem with construction companies and the housing situation has sometimes caused difficulties.

Transportation of equipment is a problem in itself, but by maintaining crews and equipment at central locations and with trucks and other mobile equipment used exclusively for pipe line work, the construction companies have been able to meet conditions. For emergency work these companies have trucks and trailers at central yards to haul equipment rapidly to the job. Even self-propelled units, such as bulldozers, are transported in this manner in order to save time and gasoline.

The maintenance work ranges from the repair of short sections of line where replacement of pipe is not necessary, to the relaying of entire lines. Virtually all joints are welded and when screwed lines are not cut the collars are welded. When a screwed line is taken up or any sections removed, the collars are cut off

A pipe cleaning machine in service during over-the-trench reconditioning operations on an 8-in. oil line in the San Joaquin Valley, California

by a cutting and beveling machine and the joints butt welded. The machine most widely used employs torch cutting, the machine being clamped to the pipe and the flame revolved around it. The machine can be set to cut at any desired degree of bevel and leaves the end of the pipe ready for welding.

Electric arc welding generally is used for most of the pipe larger than 4-in. diam. and acetylene welding for 4-in. and smaller pipe. Some 4-in. pipe is electric welded, however, and a few operators require electric welding on even smaller sizes.

When over-the-trench reconditioning is done the general procedure is to uncover and clean the pipe with a pipe cleaning machine, as shown in an accompanying illustration. The deep pits are spot-welded and, when a screwed line is thus being reconditioned, collars are welded throughout the section being worked on. A protective coating is then applied and the pipe wrapped.

Over-the-trench reconditioning permits uninterrupted service and saves the cost of hauling to and from central yards. Many lines in California, however, are very old and require considerable replacements. Service under war conditions cannot be interrupted for any great length of time so sections of line are laid and tied in with the old line as soon as the section is completed. For example, one company has its old line replaced in 7-mile sections. Pipe is strung along the first 7-mile section and welded. With this section ready for use after testing, it is tied in with the line and the 7 miles of pipe that it replaces are released for reconditioning and culling. The next 7-mile section is then constructed and when it has been tested and is ready for service one end is connected to the first section and the other to the old line, releasing another 7 miles of pipe for reconditioning.

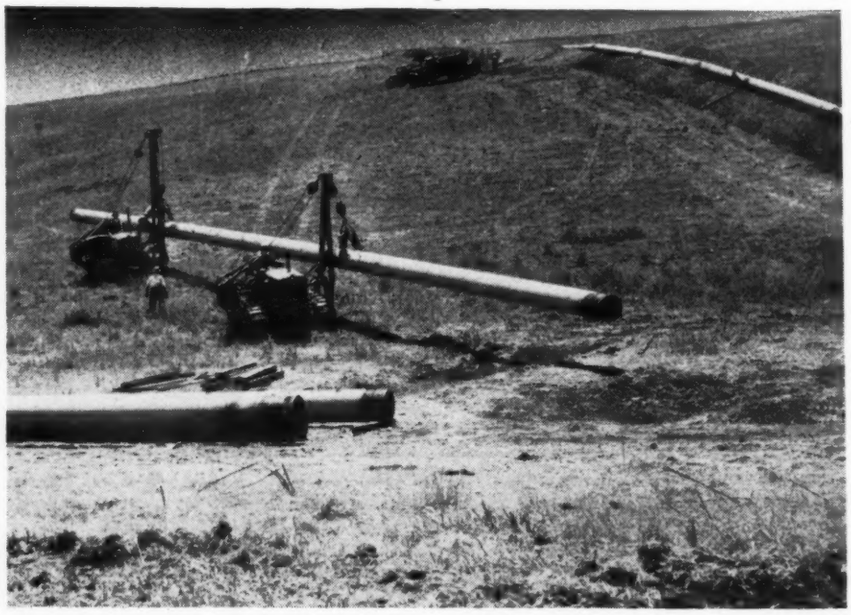
The shortage of steel obviously has necessitated the utilization of all pipe possible and reconditioning has been done both in the field and at central yards of the pipe line construction companies. Some of this work is done at the oil company yards when manpower and equipment can be spared for the work. Portability of equipment has aided in meeting conditions and reclamation service is applied where it is most effective. This service includes cleaning and straightening pipe, cutting out collars and defective welds, scarfing pipe ends, and applying protective coatings. In some cases the pipe is welded in doubles at the yard in order to utilize the facilities there provided.

In addition to pipe reclaimed from old pipe lines a considerable amount of pipe during the last two years has come from oil and gas wells. The salvaging of casing[1] from producing wells, when it can be recovered without injury to the well, has been a means of saving considerable steel in California, and although the greater part of the casing recovered from oil wells has been used in the drilling of new wells, much of the pipe not suitable for rerunning in wells has been turned over to pipe line construction. In using pipe for oil wells the pipe may be in excellent condition except that the joints are in such shape that it is better to discard the pipe for oil well service than try to recondition the joints and collars. As the pipe is welded when used for pipe line construction these bad joints are cut off at the desired bevel and made available for laying.

Southern California is so dependent on gas for fuel in its industries and homes that natural gas distribution is in itself a definite part of the war effort. The gas companies, due to manpower shortage and lack of transportation equipment, have also had to call in pipe line construction companies to take on emergency jobs formerly done by the gas company organizations, as well as to recondition main lines. A considerable part of the maintenance and reconditioning work of these companies is, in fact, now done on gas distribution systems and the sizes of pipe handled range from the smallest to largest diameters.

[1] "Casing Salvage Aids Steel Conservation," by Wallace A. Sawdon, *The Petroleum Engineer*, September, 1943.

☆ ☆ ☆

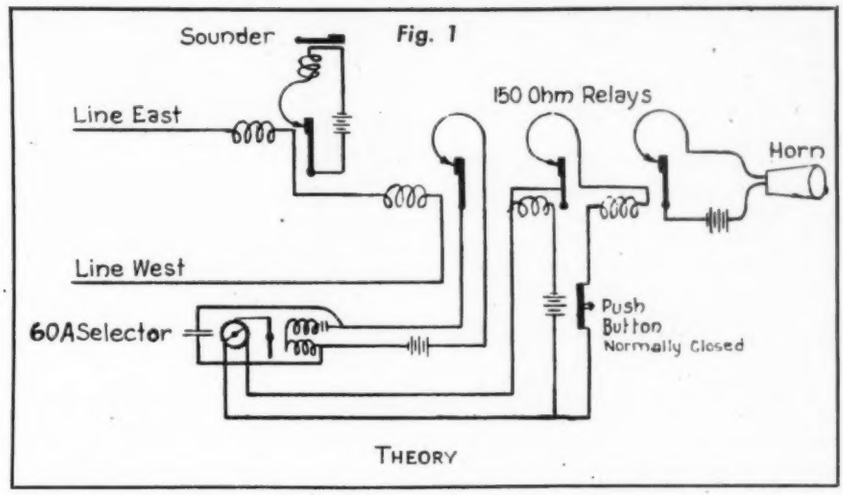


Side booms handling 20-in. pipe

PETROLEUM ENGINEER Exclusive Feature

by
F. P. O'Connor
Supt. Telegraph & Telephone
Stanolind Pipe Line Co.

Fig. 1



Selective Ringing on Pipe Line Telegraph and Telephone Systems

☆ Selector system developed to fill specific need

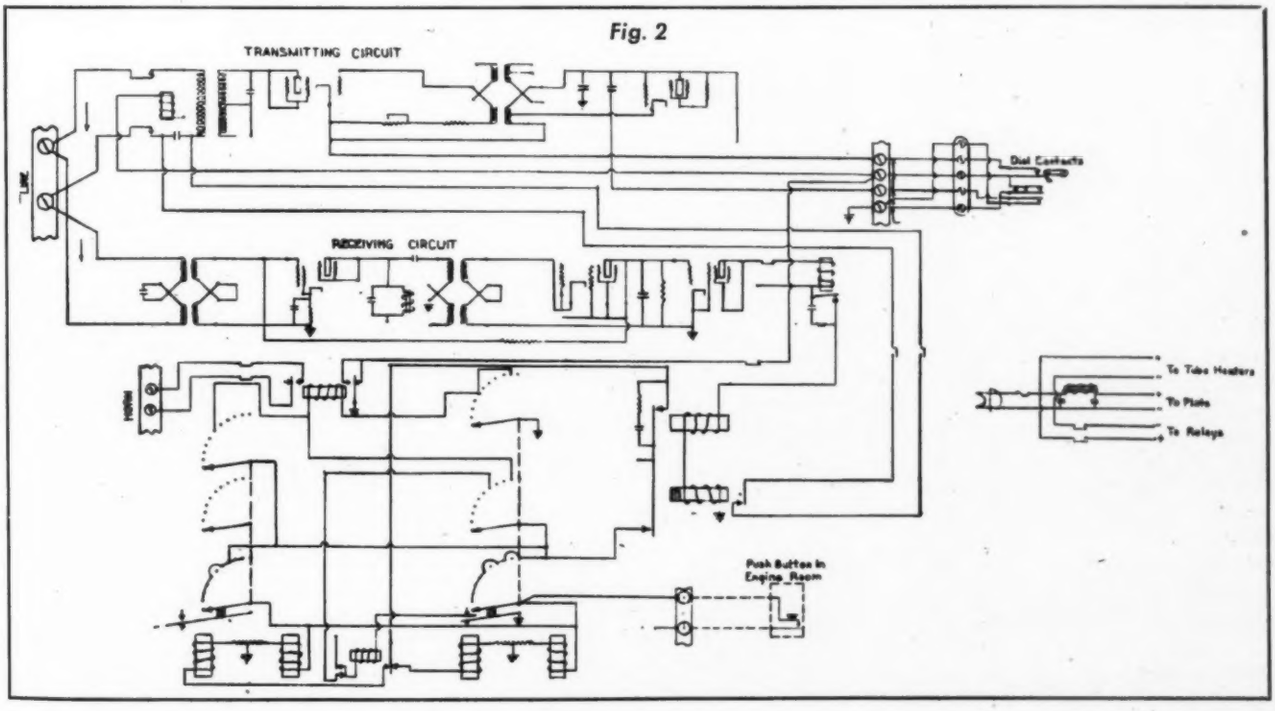
THE development of Stanolind Pipe Line Company's selector system began when the need arose for a signaling device at a point to which there was only a single line telegraph wire. To operate a howler at this station we made use of a 60-A selector to operate through a 150-ohm telegraph relay, which was used as a lock-up relay, with the howler to be released by a push button in the station office. The successful operation of this device enabled the operator to break the monotony of constantly sitting at his desk, and permitted him to perform other station duties within hearing of the howler. A schematic drawing of this device is shown in Fig. 1.

The satisfactory operation of this selector led to consideration of a similar device to be used on the company's magneto telephone system for the purpose of eliminating the almost constant operation of the howlers at each station, which is customary on long magneto lines. It appeared desirable to procure a device with which only the station or stations desired could be signaled without interfering with the use of the simplex Morse telegraph system or carrier telephone facilities that operate on the same pair of wires.

Inquiries through various manufacturers failed to produce any selective equipment that would serve our purpose, and it was then that we undertook the development and assembling of the equipment shown in Fig. 3.

First experiments were with 60-cycle ringing current, but this did not prove entirely satisfactory and it was decided to use something in the voice frequency

Fig. 2



band. We are now using a ringing frequency of 2750 cycles.

Fig. 2 shows a simplified wiring diagram of the set shown in the photograph (Fig. 3).

Power for this equipment is supplied from the station's direct-current generators. Ringing current is supplied from an oscillator tube. Employees are instructed to lift their receiver and ask "Is the line busy?" before dialing. This serves to clear the line and allows time for clearing the selectors before dialing the desired station or stations.

When it is necessary to transmit information that is common to all stations, all stations on the division can be rung simultaneously by dialing "9".

With each selector there is an "answer back" device that connects a low frequency 400-cycle tone to the line

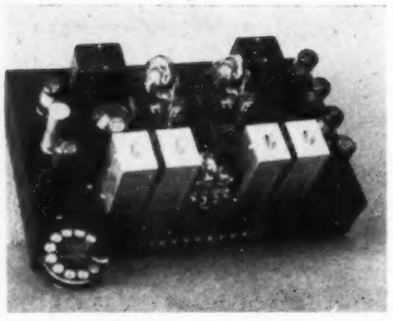


Fig. 3

when the selector at the called station has operated. The 400-cycle tone on the line notifies the calling station that the signal has operated at the called station, and also serves as a busy signal should anyone else attempt to use the line. The tone is removed by dialing "1". This is done when the called station is ready to answer or can be silenced by the calling station after the signal has operated for a reasonable length of time.

Linebox telephones are not equipped with these selective devices because the infrequent use of such instruments does not justify the expense. These linewalker stations must use the hand generator 20-cycle ringing, which operates a 2500-ohm ringer at either terminal of the line. One of these terminal stations will then dial any station to which the calling party wishes to talk.

A feature of these sets is that they do not use a grounded return signal and will operate on extremely small ringing current. It is possible to ring selectively a distant station with one or more intermediate receivers off the hook.

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P 615.635.4

Lowering Ground Bed Resistance

PETROLEUM ENGINEER EXCLUSIVE Feature

☆ Use of chemicals helps retain ground bed moisture

by Paul F. Marx

Technical Engineer, U. S. Maritime Commission

IN locations where excessively high ground bed resistances are encountered and where it is impossible to move the location of ground beds their resistance may be lowered to a marked degree by the use of a mixture of calcium sulphate and sodium chloride.

These two commercial chemical compounds can be purchased readily in virtually any locality, and they are inexpensive. The data contained in this article concerns a ground bed consisting of 60 to 70-lb. per yard "T" rails set vertically in the ground at 20-ft. centers. A plan view of the rails forms a wide "V" and the positive generator lead is connected to the center rail. After a hole is made in the ground by an auger, some water is poured into the hole, then calcium sulphate, sodium chloride, and dirt are added. The rail is alternately lifted and dropped into the hole by means of the winch and boom on a pipe line truck. This mixes the materials thoroughly. The procedure is repeated until the hole is full.

A 100-lb. sack each of calcium sulphate and sodium chloride is used to each rail. The calcium sulphate will "set-up" in a comparatively short time. This is also beneficial as the rail will not settle at a later date.

The overall circuit resistance, when using one rail without the added chemicals, is 3.75 ohms. The adding of the chemicals to the same rail lowers the circuit resistance to 2.14 ohms or a 75 per cent change based on the added chemicals. The current at 30 v. increases from 8.0 to 14.0 amp. on the one rail after the addition of the chemicals.

The accompanying chart shows the effect on lowering the overall circuit resistance by tying-in additional ground bed rails under the two conditions, with and without the addition of chemicals. It also shows the increase in ampere output (with chemicals) as additional rails are added.

These chemicals help retain ground bed moisture and the low overall circuit resistance can be maintained over a long period of time. —— ☆ ☆ ☆ ——

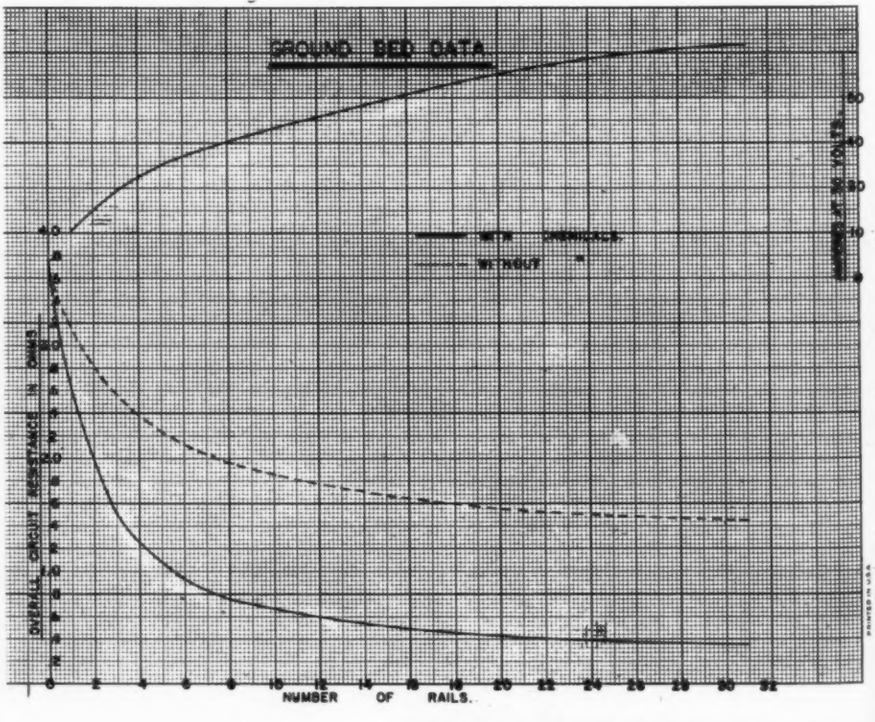

Chart of data on lowering ground bed resistance discussed in article

MINIMUM MAINTENANCE... MAXIMUM PROTECTION...

ANOTHER strategic artery of oil for war! Never before have so many vital pipelines been built with such amazing speed. But even in the emergency there has been no compromise with make-shifts. These pipelines are planned and built to give long years of service.

To assure minimum maintenance and maximum protection, the builders specified Barrett Coal-tar Enamels—those used on the longest and largest oil pipelines in the world . . . "Big Inch" and "Little Big Inch."

Engineers have discovered that Barrett Enamels can be applied easily and quickly in all sorts of weather—an important factor in speedy construction. Also, Barrett Enamels resist underground acids, alkalis, and electrolysis, and withstand unusual conditions of stress in all varieties of soil.

Again and again, Barrett Enamels have demonstrated that they meet all requirements of the most exacting users, and at the lowest possible cost.

THE BARRETT DIVISION
ALLIED CHEMICAL & DYE CORPORATION
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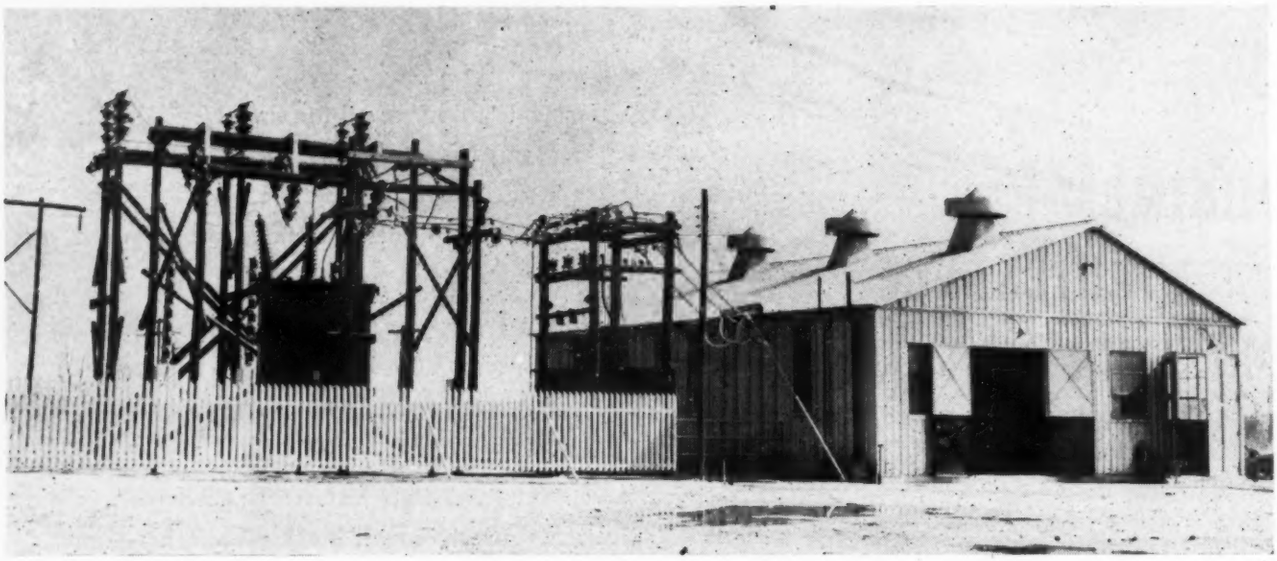
Magnolia Pipeline Company. Barrett Coal-tar Enamels.

FIELD SERVICE—*Our Pipeline Service Department and staff of Field Service men are equipped to provide both technical and on-the-job assistance in the use of Barrett Enamel.*

Barrett COAL-TAR ENAMEL



Typical pumping station on "Big Inch" pipe line

Resources Conserved By "Big Inch" Line

☆ Comparisons made between transportation of petroleum by the big line, tank cars, and tankers

PETROLEUM ENGINEER Exclusive Feature

by W. G. Taylor

Petroleum and Chemical Section,
Industrial Engineering Division, General Electric Company

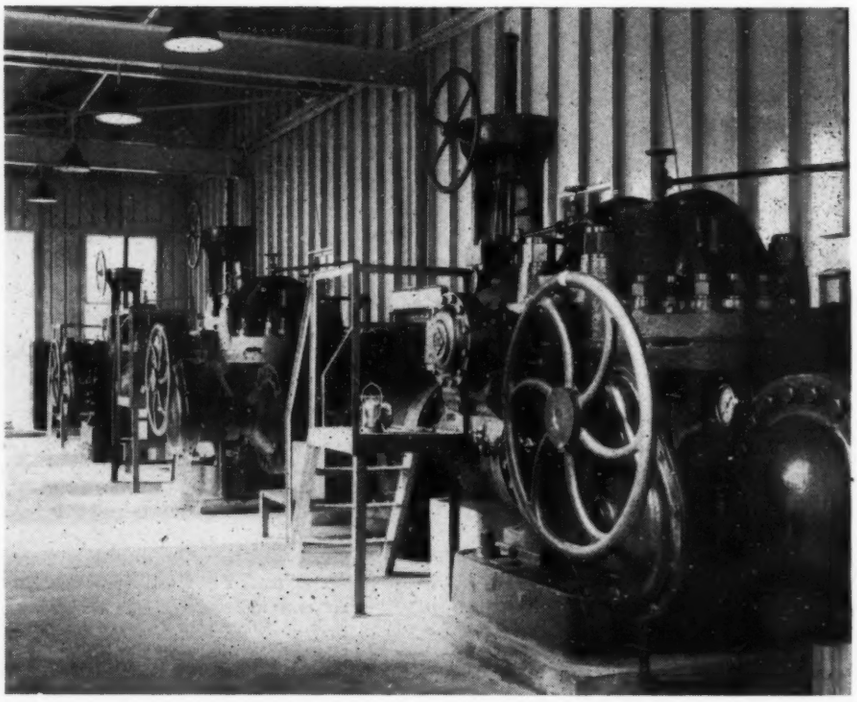
MANY questions have been asked about the "Big Inch" pipe line, the gist of which has been "Is it any better than tank cars or tankers for oil transportation, and if so, why?" One of the answers has been given by Petroleum Administrator Ickes, who has pointed out that the pipe line cannot be sunk by submarines and is less susceptible to bombing. These, however, are factors related only to wartime conditions. There are other fundamental factors involved that point out more enduring answers.

When Atlantic coastal tanker service was interrupted, the railroads performed an almost miraculous job in organizing tank car transportation from Texas to the eastern refineries and markets. The results were not only far in excess of what anyone anticipated could be accomplished, but also in excess of what could be maintained indefinitely without much revamping of equipment. Only those repairs necessary to meet the emergency were made, because the cost of tank car transportation is too high for such service for normal times. Behind this lie interesting economic considerations that involve conservation of fuel, materials, and manpower.

Tank Cars Versus "Big Inch"

The capacity of the "Big Inch" pipe line is 300,000 bbl. per day. To deliver this amount of oil daily by tank car

(*Continued on Page 119*)



Pump room in station on "Big Inch" line

(*Continued from Page 116*)

from Texas to the New York and Philadelphia refining areas, roughly a distance of 1500 miles, requires the use of approximately 25,000 tank cars and 500 locomotives, including those temporarily out of service for maintenance work or repairs. As an average tank car holds about 220 bbl., the delivery of 300,000 bbl. of oil requires the daily arrival of 1365 tank cars at the terminals. This is nearly one per minute. In other words, the "Big Inch" pipe line would fill nearly one tank car per minute, 24 hr. a day. On the assumption that these tank cars might be handled in trains of 80 cars each, 17 trains arriving each day would be required, and they would all have to return empty to their starting points.

Railroad coal consumption. The railroad fuel consumption to handle this traffic can be estimated by determining the daily gross ton-miles. The weight of the average empty tank car is estimated at 22 tons, and the loaded car 54 tons; a weight of 300 tons is assumed for each locomotive. On this basis, the gross ton-miles for each train, traveling 1500 miles loaded and the same distance empty, is approximately 11,020,000 g.t.m., and for 17 trains a day is 187,340,000 g.t.m. per day. Railroad operating records indicate that a fair assumption of the coal consumption to operate the tank car trains over the route under consideration would be 110 lb. of coal per 1000 gross ton-miles. On this basis, the total coal consumption to deliver 300,000 bbl. of oil over this route is readily estimated to be 10,300 tons per day.

Coal consumption for electric power. Now consider the generation of electric power in coal burning central stations, to supply the electrically operated pumping stations on the "Big Inch" pipe line for daily delivery of the same amount of oil. With 26 pumping stations in operation—each having three 1500-hp. pumps — and the additional suction head booster pumps and ventilating fans installed on the 24-in. pipe line system (all electric motor driven), the connected load to pump the oil from terminal to terminal totals 119,328 hp., in operation 24 hr. a day, resulting in an estimated power consumption of 2,135,000 kw-hr. per day exclusive of line and transformer losses. These losses, with allowances made for the high losses in the steel wire line extensions to many of the pumping stations, are added at an estimated 10 per cent, making a total of approximately 2,348,500 kw-hr. generated daily at the central station bus-bars. It is believed to be a fair assumption that these power stations can generate a kilowatt-hour of electric power and put it on the bus with a consumption of 16,000 B.t.u. in a coal-fired plant. If coal is assumed to have 25,000,000 B.t.u. per short ton, the estimated coal consumption to keep the pipe line in operation at full capacity is 1500 tons per day, as compared with 10,300 tons required by the railroads. As a means of conserving coal, the pipe line is therefore highly important.

Oil fuel consumption. If the locomotives all burned oil instead of coal, the equivalent consumption for tank car operation would be approximately 35,700 bbl. per day, which is 11.9 per cent of the capacity of the 24-in. pipe line. On the other hand, if the electric power stations used oil fuel, their equivalent consumption would be 6750 bbl. per day, which is only 2.25 per cent of the capacity of the pipe line. This illustrates even more clearly the importance of the pipe line as a factor in the national economy. This difference in consumption of either coal or oil is accounted for by the difference in thermal efficiencies in steam locomotives and in central electric power stations, and by the fact that the tank cars have to be hauled back empty.

Manpower. In manpower required, the pipe line has an immense advantage over the railroads. The "Big Inch" line employs about 216 station operators, counting all shifts; the supervisory personnel probably increases the total

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● *Photograph shows Reilly Enamel being applied to a section of the "Little Big Inch" pipe line.*

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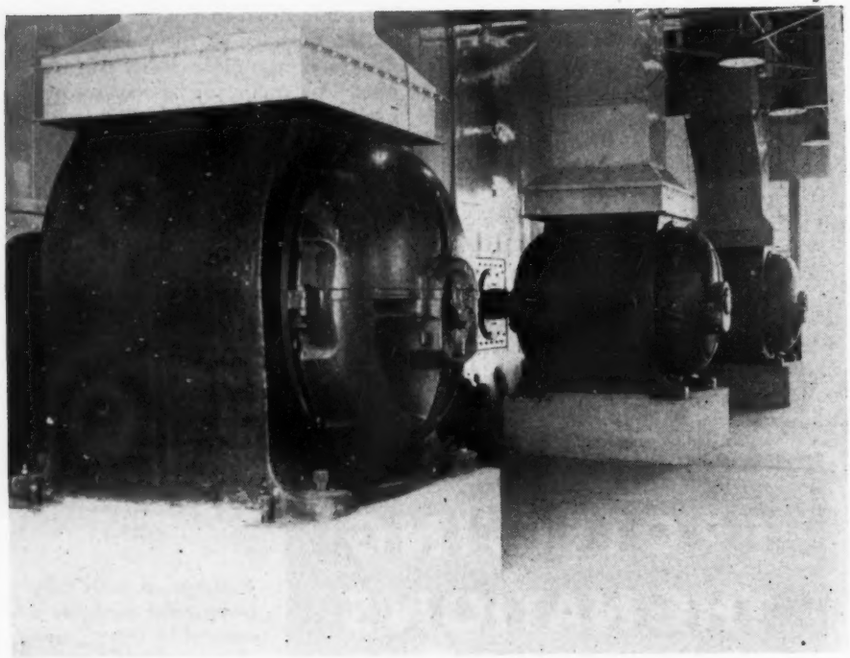


1500-hp. induction motors are prime movers in pumping stations

roughly to 250 men. On the railroads, more than 300 locomotives must be on the road at all times to maintain transportation of 300,000 bbl. of oil a day from Texas to the East, requiring more than 1500 men for train crews, to which are added the men required for supervision, which may bring the total to 1600 men, not including men assigned to the runs but off duty. It is easy to see that in economy of manpower, the pipe line is beyond comparison with tank car transportation.

Steel. The railroad equipment was available, but it is interesting to contemplate that the amount of steel in the 25,000 tank cars and 500 locomotives, which is estimated to be 700,000 tons, is nearly twice the 367,000 tons of steel used in the 24-in. pipe line project, including all auxiliary pumping units and storage and terminal equipment.

Operating costs. All these factors make it evident why the cost of transportation of oil by rail must be so much higher than by pipe line. Available information on railroad operation shows that their operating expenses in 1940, exclusive of fixed charges, averaged $2.34 per 100 gross ton-miles. For the 187,340,00 g.t.m. per day, which is estimated for tank car operation in transporting and delivering 300,000 bbl., the total daily operating expense figures $438,000, or $1.46 per bbl. Compare this with the cost of 15.2 cents per bbl. for the pipe line, as estimated by W. R. Finney and J. B. Adoue.* They point out further that present pipe line tariffs (not costs), via existing small diameter pipe lines, are 67.5 cents per bbl.

*"The Big Inch Pipe Line," by Wallace R. Finney and J. B. Adoue, *Mining and Metallurgy*, October, 1943, pp. 440-445.

Tankers Versus "Big Inch"

After the war, tanker transportation up the Atlantic coast will be resumed, as the eastern requirements for oil and gasoline are much greater than the capacity of the available pipe lines. Finney and Adoue have shown that the cost via "Big Inch" pipe line will be competitive with that via tanker.

Fuel consumption. It has been estimated by Finney and Adoue that to maintain an average delivery of 300,000 bbl. per day, a total of about 36 tankers with an average capacity of 116,000 bbl. each would be required. Such data on tanker fuel consumption as is available indicate that it might be assumed as 0.55 lb. per shaft-horsepower-hour, which figures 196 bbl. per day for a 5000-hp. tanker, or approximately 7000 bbl. per day to make the required oil delivery. When this is compared with the oil fuel consumption of 6750 bbl. per day estimated to produce electric power to operate the "Big Inch" pipe line, it is seen that the matter is practically a stand-off. The probability is, however, that the advantage is somewhat in favor of tankers, because the foregoing figures make no allowance for reduced fuel consumption when the tankers return in ballast.

Steel. A tanker of the size under consideration weighs approximately 6000 tons or less, with all tanks empty, making a total of 216,000 tons or less for 36 tankers. This is a materially lower total weight than the 367,000 tons of steel in the pipe line project, and is a factor in favor of tankers under normal conditions. Obviously, it could not influence the decision to build the pipe line, made under war conditions, when it was a question of transporting oil by tank cars or by pipe line, or not at all.

Manpower. Transportation by water requires more men. With 50 to a tanker, a total of 1800 men is needed for the 36 tankers, but only about 250 for the pipe line. Labor is a large factor in the total operating cost, but because of this one should not jump to an erroneous conclusion that tankers cannot compete closely with the 24-in. line. The true picture can be obtained only by a consideration of many other factors, including fixed charges as well as all operating expenses, with due weight being given to such matters as relative useful life and susceptibility to interruption of service, all of which are beyond the scope of this discussion.

Summary

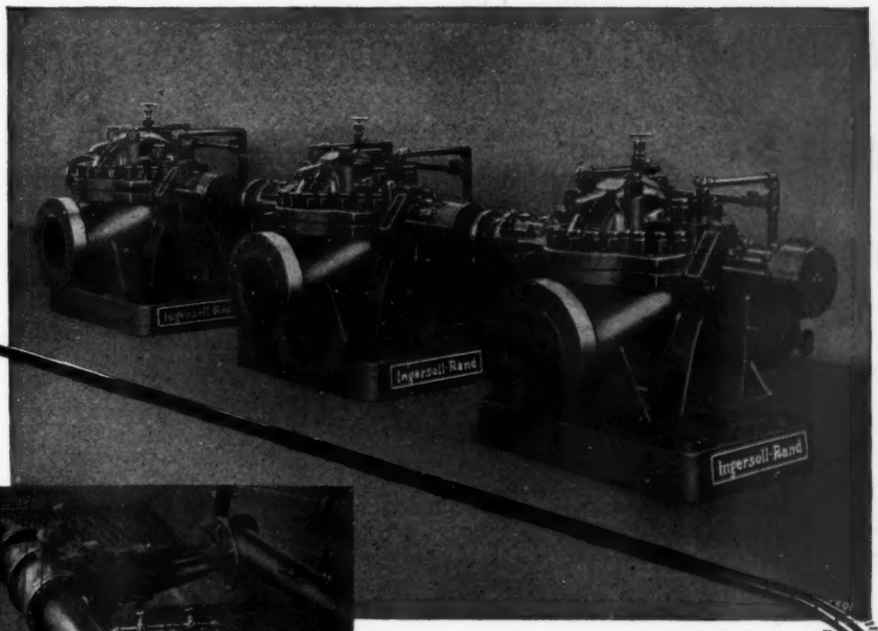
It can be seen that it was of importance to build the "Big Inch" pipe line to conserve the national fuel supply and to release many of the railroad cars required for its transportation, and to reduce the manpower and railroad equipment tied up by tank car transportation so that it could be devoted to the even more important job of moving the vast amount of other freight largely destined for the war fronts. The relative amounts of steel required for the several means of moving the oil played very little part in the decision to build the pipe line, because tanker service could not continue and tank cars were already available. Fundamentally, the decision was made because available railroad equipment was not sufficient to supply the East with all the oil needed. The necessarily high cost of railroad transportation and the difficulties and time required to increase the railroad facilities made the pipe line necessary. The only question of materials involved was whether steel and copper would be available for the project, and this was allotted after it was eventually determined that it could be spared.

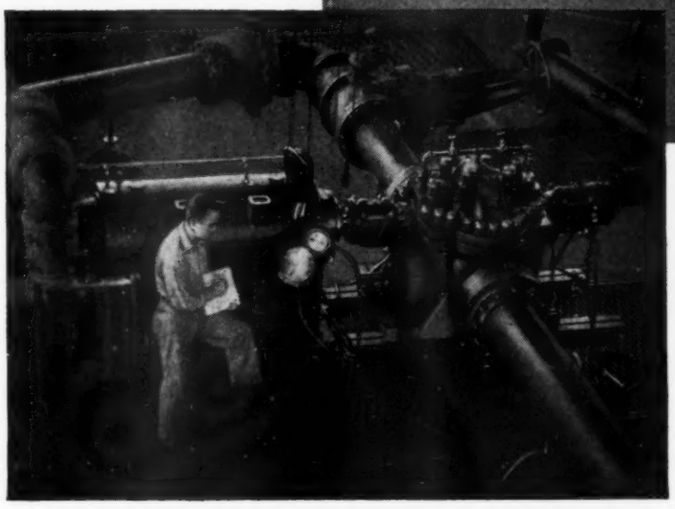
☆ ☆ ☆

TABLE I

SUMMARIZED COMPARISONS

	"Big Inch"	Tankers	Tank cars
Coal consumption, tons per day	1500	.....	10,300
Oil consumption, bbl. per day, if used	6750	Under 7000	35,700
Manpower required	250	1800	Over 1600
Steel required, tons	367,000	216,000	700,000
Operating costs per bbl.	$0.152	Approx. $0.152	$1.46





(Above) There are three pumps operating in series in each station against a total head of 800 psi. These pumps which were designed especially for this line are single-stage, double-suction, and direct-connected to 3750 rpm motors.

(Left) One of the pumps on test.

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It takes millions of gallons of gasoline and oil to win a war. The 20-inch War Emergency Products Line will deliver every day nearly 10,000,000 gallons of gasoline and fuel oil to points where it is most needed. Forty-one Ingersoll-Rand pipe-line pumps, each driven by a 1500 hp electric motor, will be installed on this new line.

These pumps are similar in design to the thirty-six larger Ingersoll-Rand pipe-line pumps now serving the "Big-Inch" Crude Oil Line.

There is much more to the story... I-R engine-driven compressors help to get petroleum from the earth... I-R pumps are used in hundreds of refineries... I-R pumps are used in most of the tankers...I-R portable compressors and tools help to lay the pipe lines... and I-R products serve in many other phases of the petroleum industry. Ingersoll-Rand Company, Cameron Pump Division, 11 Broadway, New York 4, N. Y.

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P 615.63

Servicing and Repairing Magnetos

PETROLEUM ENGINEER Exclusive Feature

☆ Thorough knowledge of magnetos by station mechanic results in better operation of machinery

by J. W. J. Bercher

Tide Water Associated-Seaboard Oil Company

IT is common practice to carry in stock a spare magneto of each type used. This is good practice. Under present conditions many may fail to take advantage of the fact that magnetos for use on 4, 6, or 8 cylinder machines are readily interchangeable. It is the considered opinion of the writer that the plant mechanic should become thoroughly familiar with the theory and construction of the magnetos in use in his station and be able to make such changes when required.

As many competent mechanics have had no chance to become familiar with the theory involved they are badly handicapped in ignition trouble shooting and many magnetos are changed and sent to the repair shop for repairs that might be made on the spot.

The magneto is essentially simple. It consists of a magnet, a coil (with both a primary and a secondary winding), a set of breaker (or interrupter) points, a condenser, and a switch. There can be only a limited number of failures with so few parts involved. The trick is to be able to determine the cause of failure from the symptoms and the exact steps necessary to restore the magneto to its proper function.

The proper function of the magneto is to produce a high voltage current that will reach the spark plug and ignite the charge in the cylinder at the proper time. Because the pressure in the cylinder is high the voltage required, in the case of most magnetos, is about 30,000 v. Such high voltages are not readily produced directly, so the need for the coil is apparent. A relatively low voltage current is produced in the primary winding, which acts upon the secondary winding to produce the required voltage.

Producing Current

The logical question at this point is, "How is the current produced?" An electrical current is produced in a conductor whenever that conductor is cut by a magnetic field. A conductor is any material that will allow an electrical current to pass through. Copper is the most common conductor. A magnetic field is the space covered by the magnetic lines of force. In the case of a bar magnet the paths taken by the magnetic lines of force may be easily seen by taking a sheet of white paper and placing it over the magnet and sprinkling iron filings upon the paper. The resulting pattern will resemble Fig. 1. The notations N and S in the figures refer to the north seeking and the south seeking poles. The significance of these terms may be easily checked with a compass. The same experiment if performed with a horseshoe magnet will give a pattern resembling Fig. 2.

Magnetic fields also exist in the space surrounding conductors in which current is flowing. The writhing of a welder's cable, if lying loose in the box when the arc is struck, is a very good demonstration of the existence of such fields. If a conductor is passed through a card sprinkled with iron filings, the resulting pattern will resemble Fig. 3.

The lines of force about a conductor follow fixed laws. Their direction may be found by application of the right hand rule. If the right hand grasps the conductor with thumb pointing in the direction of the current the fingers will indicate the direction of flow of the magnetic lines of force.

Whenever a conductor is cut by a magnetic field a current is produced if the conductor provides a circuit. The manner in which a condutor is cut by the magnetic field may be any one of the following:

1. A fixed conductor and a movable field.
2. A fixed field and a movable conductor.
3. A movable field and a movable conductor.
4. A conductor and a variable field.

Magnetos fall in the fourth of the above classifications. The mechanics of one popular make of magnetos is illustrated in Figs. 4, 5, 6, and 7. These figures represent successive stages in the cycle of events in the magneto, "a" and "a'" represent the point of entry of the magnetic flux and the point at which the flow path is completed; "b" is the core about which the primary and secondary windings are wrapped. The flow of the magnetic flux will follow the path of least resistance as will water, in this case the path of least resistance is to "a" and then through the core "b" back to "a'". This flow of flux results in magnetizing the core. In the postion indicated in Fig. 5 there is no flow through "b" and in the postion in Fig. 6 the flow is the reverse of that in Fig. 4. So it is apparent that as the magnet turns the core "b" is periodically charged and discharged.

It is a characteristic of the magnetic flux that while flowing through a mag-

(Continued on Page 126)

Fig. 1

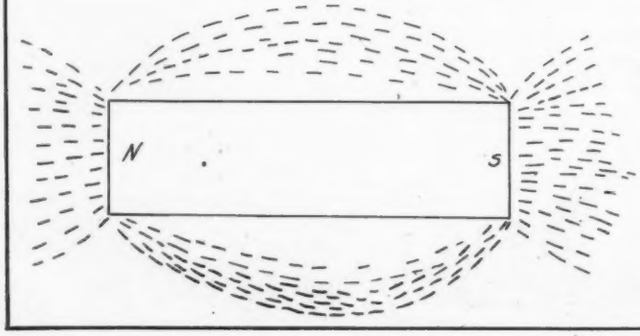
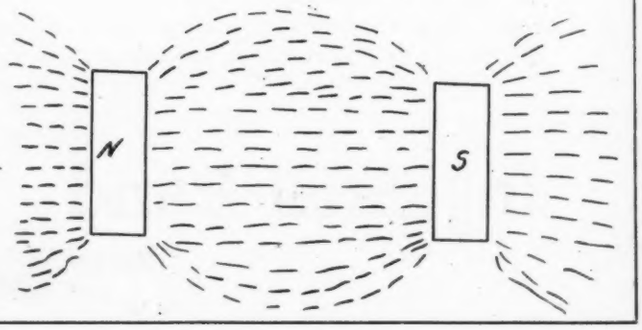


Fig. 2



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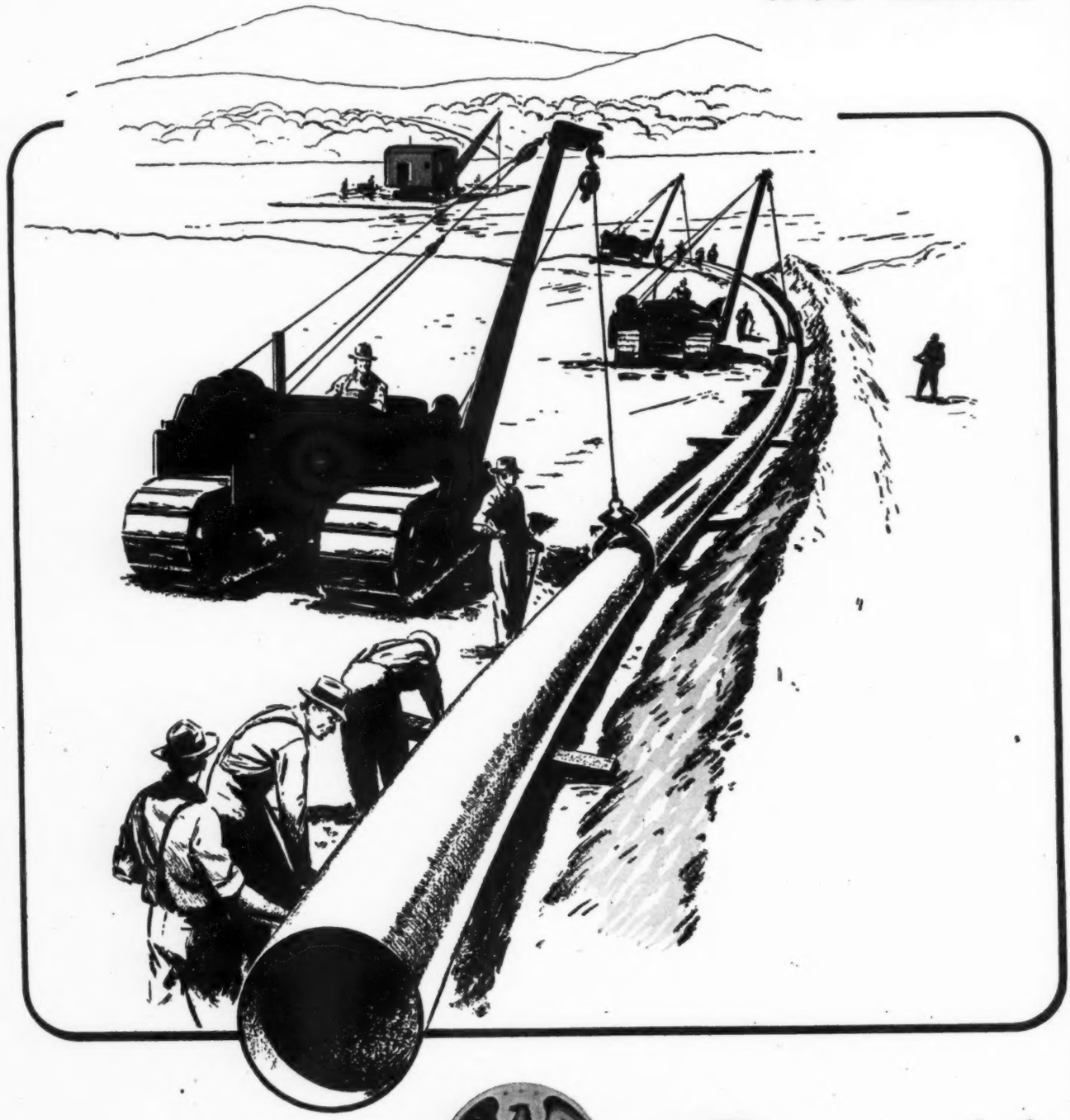

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"LINE-TESTED" ELECTRIC WELD LINE PIPE

(Continued from Page 122)

netic material it will magnetize that material. The readiness with which various magnetic materials become magnets when subjected to a magnetic field, or give up their magnetism when removed from the magnetic field, is subject to wide variation for different classes of magnetic substances. Soft iron is used as a core material because of the readiness with which it assumes or gives up its charge. Cores are usually made up in laminated form, that is, of many thin sheets or laminations, this construction having been found superior.

Component Parts

We have seen that the core of the magnet is successively magnetized and demagnetized as the magnet revolves. The relationship of the component parts of the magneto are shown in Fig. 8. Fig. 8 shows the primary winding wrapped about the core. The primary is made up of a comparatively few turns of heavy wire, whereas the secondary winding is made up of many turns of fine wire. The ratio of turns between the primary and the secondary determines the voltage that the magneto will deliver to the spark plug. It will be noted that both the primary and the secondary are grounded at one end. The primary circuit is completed through the breaker points, one of which is also grounded. As the metal between the ground connections offers a path for the current, a complete circuit is had when the points make contact. The primary circuit also is connected to a condenser, which is grounded. The secondary connects to the distributor rotor, which contacts the distributor brushes. The distributor brushes are connected to the spark plugs, which are grounded, thus both the primary and secondary circuits are completed through the ground. As it is necessary to hold the resistance in the primary circuit to as low a value as possible the ignition switch is connected from the primary circuit to the ground. (We will see, after analyzing the function of the parts of the magneto, why this arrangement works.) The lead from the secondary to the distributor rotor is connected to the ground across a safety gap. This safety gap will provide a path for the high tension current if for any reason the normal path through the spark plug is blocked.

As the magneto turns into the position shown in Fig. 4 a magnetic field is set up in the core, which disappears as the position in Fig. 5 is reached. This field, as it builds up and as it collapses, cuts the primary winding, satisfying the requirements for the production of an electrical current in the primary. As the voltage produced in the primary depends upon the rapidity with which the

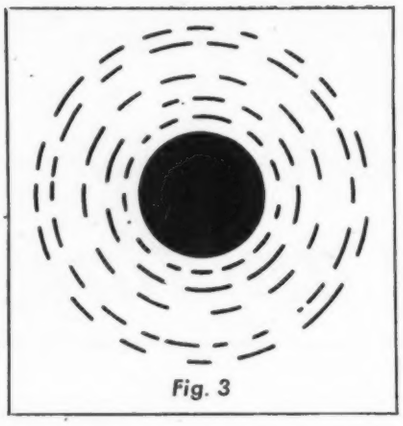


Fig. 3

field is built up and collapsed, or more properly upon the speed at which the primary is cut by the magnetic lines of force, some additional mechanism is required to insure that the magneto will turn at the proper speed when starting the engine. This is the function of the impulse coupling. This device is provided as a means for turning the magneto at a higher rate while starting the engine than would be possible were the magneto directly connected to the gear train. The impulse coupling also retards the spark a predetermined amount for easier starting. If no impulse coupling is provided a booster magneto or a "hot shot" is usually necessary. The booster may be wired to use the distributor in the magneto.

As we learned from the experiment illustrated in Fig. 3 a conductor through which current is flowing sets up a magnetic field. Therefore, as current is generated or induced in the primary winding, a magnetic field is set up that cuts the secondary winding. This field must be made to cut the secondary as rapidly as possible and it is here that the function of the breaker points and of the condenser are of paramount importance.

The breaker points are opened and closed by a cam that is designed to cause the points to act upon the primary circuit in a manner that will produce the maximum current in the secondary. The relationship between the position of the cam and the position of the magnet is fixed for each magneto. When the relative positions of the cam, the magnet, and of the distributor rotor are not properly fixed the magneto is said to be out of time internally.

Function of Condenser

A proper understanding of the function of the condenser requires additional discussion. An electromotive force (electric current), when applied to an insulated conductor such as a piece of tin, will produce an electrostatic charge upon the surface of the conductor. That is, if a conductor of the type mentioned is well insulated and connected to one terminal of a battery the other terminal of the battery being grounded, electric-

Fig. 4

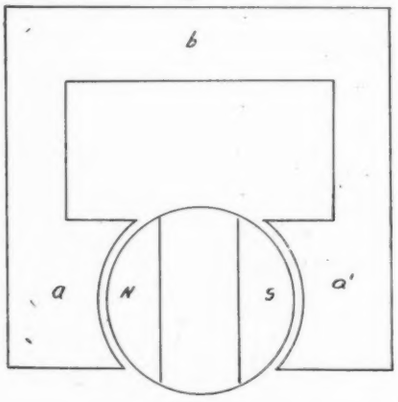


Fig. 5

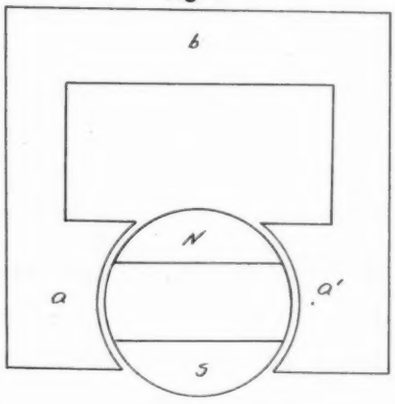


Fig. 6

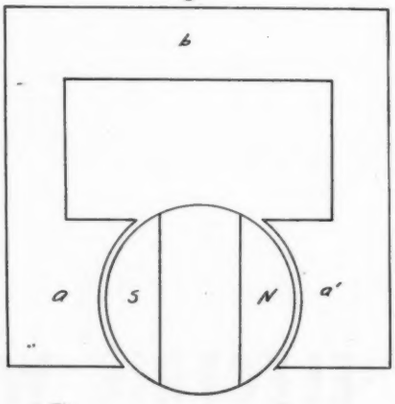
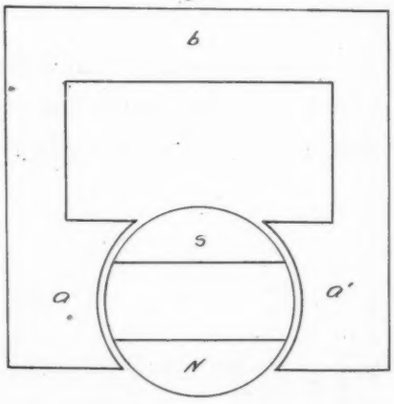


Fig. 7



ity will flow into the sheet of tin and appear upon its surface as an electrostatic charge. Experimental determinations indicate that a charge cannot exist on a conductor except in the presence of an equal and opposite charge upon the surrounding bodies. This second induced charge is always of opposite polarity to that of the first charge. If the conductor is grounded it will lose its charge, but the charge of opposite polarity on the surrounding bodies will still be held, although not connected to the first body or its source of electromotive force.

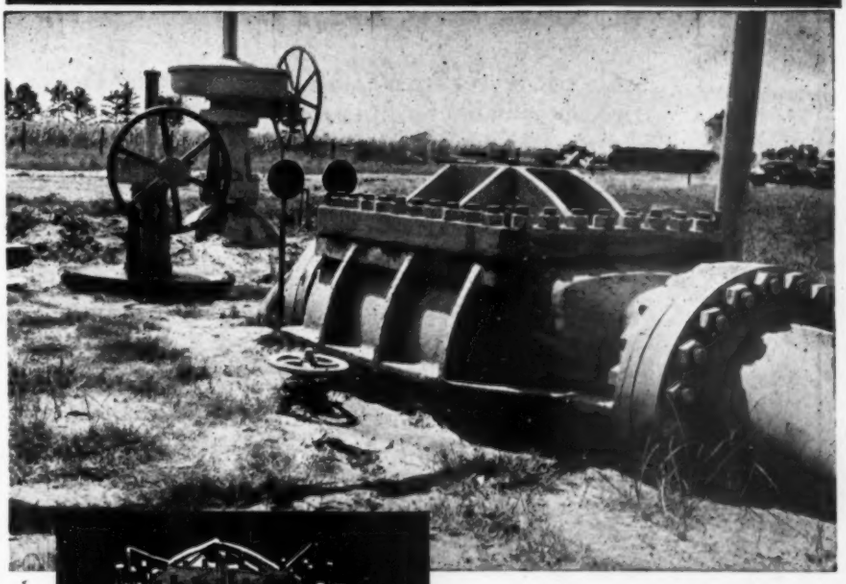
The action by which bodies are charged through an insulating medium is termed electrostatic induction, and the arrangement of two insulated conductors separated by an insulating material constitutes a condenser. The capacity of a condenser, or its ability to receive an electric charge, varies in direct proportion to the area of its plates, inversely as the square of the distance between the plates and directly as the specific inductive capacity of the dielectric (insulating material). Condensers used in magnetos are usually made of alternate layers of tinfoil and waxed paper tightly pressed and rolled together. A condenser will allow an alternating current to pass but will prevent the flow of direct current. A condenser when charged will retain its charge for some time unless discharged. If the leads from a charged condenser are placed in contact a spark will be noted as the equal and opposite charges flow together and neutralize one another. If due to age or the imposition of excessive voltage the insulating material between the plates of a condenser fails the condenser is of course no longer serviceable. Indeed it is no longer a condenser, as the plates of a condenser must be insulated one from the other. The gradual weakening of the insulation short of a complete breakdown will result in a loss of capacity.

Another factor should be considered before discussing the operation of the magneto. It is known that a magnetic field is formed about a conductor when current flows through that conductor. It also is known that current is generated or induced when a conductor is cut by magnetic lines of force. If these facts are put together the phenomenon called "self induction" can be readily understood. When the flow of current is cut off or interrupted suddenly the magnetic field about the conductor collapses and moves in toward the center of the conductor, where it disappears. This movement of the magnetic field must cut the conductor, which will produce a current in the conductor. The same phenomenon is observed when a current is suddenly set in motion for similar reasons, the path of the field being from the center outward. In the case of a coil each turn in the winding is acted upon by the collapse of the field surrounding the adjacent turns, leading to a marked increase in the magnitude of the self-induced current.

We are now in possession of all the necessary facts and are ready to tie them all together and see why and how each part is made to perform its function.

As the magneto turns into the position of Fig. 4 or Fig. 6, a magnetic field is set up in the core, which cuts the primary winding inducing a current in the primary circuit. This current reaches a maximum at the positions shown in the figures. As the magnet reaches the position that results in maximum flux density a maximum current flows in the primary circuit. In this position the breaker points are in contact and as the magnet moves past center the breaker points open. When the points open the magnetic field set up by the current flowing in the primary begins to collapse, setting up a current in the secondary and at the same time setting up a self-induced current in the primary that tries to continue to flow as the points open. If an arc were set up across the points the collapse of the field about the primary would be delayed and the current induced in the secondary would not reach

WHEATLEY'S
Streamlined Strainer on the 24"
WAR EMERGENCY PIPE LINE



The WHEATLEY STREAMLINED STRAINER fits directly into the pipe line eliminating all drop pressure. The necessity of digging a pit, as is customary when installing the old vertical type, is also eliminated.

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the desired value. Obviously, the points would be burned. The reason for the condenser should now be apparent, for we know that as the current flowed through the primary the condenser received an electrostatic charge, which it will retain so long as the electromotive force acting upon it is unchanged. As the points open the current ceases to flow and the condenser discharges through the primary. The effect of this discharge acts against and neutralizes the self-induced current. The effect of this neutralization is to give a much speedier collapse of the field about the primary and to prevent arcing at the points. Many machinists seem to believe that, as arcing at the points is a symptom of condenser trouble, the condenser is installed to prevent such arcing. This is incorrect. The object is to build up and then to collapse certain magnetic fields in a manner to produce the maximum effect in certain conductors. Introduction of the condenser offers the best way to control the collapse of the primary field and the fact that proper functioning of the condenser will prevent arcing at the points is no more than evidence that the condenser is doing its job properly and that the collapse of the primary current is being controlled in a manner to produce the desired effect upon the secondary. From this behavior of the primary current it can be seen why the switch may be connected as it is. From Fig. 8 it is learned that the switch shorts out the breaker points when closed, which leads to a gradual rather than a sudden collapse of the primary field. This prevents the secondary voltage from reaching a value that will fire the plug.

Secondary Circuit

With parts in the primary functioning properly, we are ready to consider the secondary circuit. As the secondary coil is wrapped about the primary winding the magnetic field set up by the current flowing in the primary circuit must cut the secondary winding. As has been seen, the parts that constitute the primary circuit are made to function in a manner to set up this field and then to produce its instantaneous collapse. The relatively great number of turns in the secondary when cut by the collapsing primary field results in voltage of the proper value being induced in the secondary circuit. Such voltages are hard to insulate and in order to guard against short circuits in the secondary coil a safety gap is built into the magneto. This safety gap acts as a relief valve if the voltage exceeds a predetermined value. If no safety gap were provided an accident that opened the path through which the secondary flows might result in the failure of the winding. This might be accidental removal of a high tension lead from the distributor, a badly burned spark plug, or similar trouble.

The secondary winding connects to the distributor rotor, which contacts the distributor brushes in the proper order. From the distributor brushes the high tension cables conduct the secondary current to the spark plugs.

The troubles or malfunctions that may be encountered fall into certain categories, which may be enumerated as follows:

1. Trouble in the magnetic circuit.
2. Trouble in the primary circuit.
3. Trouble in the secondary circuit.

Trouble in the first group is rare and usually is a result of partial loss of magnetism from the permanent magnet. Such loss of magnetism may result from excessive heat or vibration or both. As this trouble cannot be corrected in the field, it is not considered necessary to go into detail. It is well, however, to have magnets recharged whenever the magneto is sent in for overhaul.

Trouble in the primary circuit may be due to one of the following:

1. Trouble in the winding.
2. An open or short circuit in the wiring.

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This business-managed, privately-owned, tax-paying utility company, under the American system of free enterprise, has been able to establish an unusual record of production in war-time. Under the same system future demands for efficient economical power will be met.

SOUTHWESTERN
GAS AND ELECTRIC COMPANY

3. Trouble in the points.
4. Trouble in the condenser.
5. Magneto out of time, internally.

Trouble in the winding is rare and cannot usually be repaired in the field. If an ohmmeter is available the winding may be checked but unless a spare coil is available the check is of questionable value. Trouble sometimes occurs in the wiring. This trouble can be located many times by close examination. A testing device may be made from a flashlight that will expedite tests of this nature and will be of real value in setting the timing of the magneto to the engine. The circuit for such a test rig is shown in Fig. 9. In using this device to set timing the leads are connected across the points and when the light goes out the points are just opening. This method is much more accurate than the use of cigarette paper or thin cellophane as a feeler. If this device is to be used in engine rooms where gas may be encountered proper precautions must be taken to avoid sparks.

Point Trouble

Point trouble is quite common and often encountered. It may result from burned or pitted points, from spiked points, or from improperly gapped points. If burning or pitting is not severe the points may be restored by filing, followed by regapping. Extreme care must be taken to insure that the points make even contact over their entire area. The effect of burned or pitted points is to reduce the current flow through the primary due to the increased resistance. Any decrease in current flow will reduce the field about the primary, which will in turn result in a decrease in the secondary voltage. Failure to provide full contact area will result in a less pronounced case of the same trouble. Spiked points usually result from arcing and have the characteristic appearance shown in Fig. 10. This is caused by metal from point "A" being deposited upon point "B" in much the same manner that the weld metal is deposited by the electric welder. The effect of this trouble is to reduce the effective gap and thus lead to more pronounced arcing, which in turn interferes with the proper collapse of the field about the primary with the resulting loss in secondary voltage. It should be apparent now that each trouble can be analyzed for the effect it will have upon the secondary voltage.

If the points are improperly gapped they will be out of time in that they will not open at the proper time to produce the desired effect upon the secondary voltage. If the gap is excessive the points will open after the position of maximum flux density and vice versa.

Serious condenser trouble is readily determined from the excessive arcing at the points, which accompanies this trouble. A weak condenser may prevent excessive arcing at the points while failing to provide the proper collapse of the primary field, which will in turn lead to a weak secondary current. If after a thorough check no other trouble can be found it is often well to change condensers. The condensers thus changed on suspicion should not be discarded until they have been tested.

As most magnetos are so designed that they may be run either clockwise or anti-clockwise, depending upon which timing marks are lined up on assembly, it is quite possible for careless assembling to result in a magneto being out of time internally when it is returned from the shop. That is, the cam, the magnet, and the distributor points do not bear the proper relationship one to the other, and proper functioning of the magneto is impossible. To check this trouble the machinist should become familiar with the internal markings of his magnetos so that he may be able to inspect for such trouble magnetos returned from the shop. This is a rare occurrence, but owners of magneto repair shops are having trouble getting and keeping competent men the same as pipe line station operators. In most cases

Don't skate on thin ice

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the gears are marked with an "a" for anti-clockwise and "a c" for clockwise rotation. These marks are to be aligned with the keyway in the main shaft of the magneto. The cam is marked in a similar manner. A thorough understanding of the function of each part of the magneto is essential in making this check. The writer has seen a cam that was marked backward at the factory. Trouble of this nature is likely to be rather hard to find. The cam must be watched closely for any wear, as a change in profile will result in the points opening at the wrong time. In examining a magneto to become familiar with the markings and the interrelation of the parts close attention should be paid to the position of the magnet relative to the path of the magnetic flux, keeping in mind that the points must open at the point of maximum flux density. The position of the distributor rotor relative to the brushes should be checked, keeping in mind that the spark plug will fire as the points open, as this is the point at which the secondary is cut by the collapse of the field about the primary.

The somewhat monotonous reminder that various troubles may all be analyzed for the effect they will have upon the secondary voltage, serves to drive home the point that the sole purpose of the magneto is to deliver the proper voltage to the spark plug at the proper time and that every adjustment should be made with this fact in mind. If the mechanic will study each part of his magneto from this angle he will soon be more than repaid by the greater ease with which he can make necessary repairs and adjustments. The best approach to any electrical problem is by way of the circuit diagram. Learn to draw the circuit diagram and then from a study of the circuit and of the symptoms of the trouble observed the source of trouble can be localized readily; then its exact nature can be determined.

Check Spark Plugs

Most trouble in the secondary may be traced to the spark plugs. Dirty, badly burned plugs will always require that the magneto deliver a higher voltage than that for which it was designed and will lead to an early failure. Spark plugs should be checked on a regular schedule. The mechanic should not wait until the engine falls off the line to decide that the plugs need changing, cleaning, or regapping. A few routine inspections will allow the mechanic to predict with a fair degree of accuracy just how long a plug may be expected to last and he may then head off a large part of his magneto trouble.

Failure of the secondary circuit may result from the accumulation of carbon dust in the distributor, which may cause short circuiting. This trouble can be avoided by cleaning the distributor each time the spark plugs are changed. The cleaning should be done with a hard woven rag or fine sandpaper followed with a cleansing powder. Do not use emery paper or crocus cloth.

There is a phenomenon associated with high tension currents that is called the corona effect, or high tension leakage. This effect manifests itself as an actual leakage of electricity out of the conductor into the surrounding atmosphere. At night a glow may be seen along old high tension leads that are leaking badly. The insulation on spark plug wires is made very heavy to minimize this loss and these wires should be replaced as soon as the insulation begins to break down. This is especially true on large engines on which leads 10 ft. or more in length are common. Many times an engine may be kept on the line after severe leakage has developed by pulling the lead out of the conduit and stringing it directly to the plug. One solution of the problem is to install a high tension coil at each plug and distribute low tension current. This is being done with satisfactory results on some of the newer engines.

SHEEHAN

•

SHEEHAN PIPE LINE CONSTRUCTION COMPANY

JOHN B. SHEEHAN, *Manager*

National Bank of Tulsa Building

TULSA, OKLAHOMA

There is in the secondary coil an acute danger of short circuits due to extremely high voltages. A short between turns in the winding will reduce the capacity of the coil and result in a lowered secondary voltage. The only practicable repair is the installation of a new coil.

Ignition Timing

The work of setting a magneto in time with an engine is explained in most engine instruction books. The average mechanic can perform this operation in a satisfactory manner. How many mechanics have thought through the various operations involved and considered why the gear ratios are different for each engine type? Consideration of the following statements will lead to a better understanding of ignition timing:

1. The distributor rotor must turn at a rate that will fire the cylinders of the engine at the proper time.

2. The breaker points may open twice with each revolution of the magneto shaft (at the position of Fig. 4 and of Fig. 6).

3. The distributor rotor must make contact with a brush as the points open.

4. For a given number of cylinders the gear ratio for a two-stroke cycle and for a four-stroke cycle engine will not be the same.

5. The cam profile will depend upon the gear ratio and upon the number of cylinders.

If a magneto from a four cylinder two stroke cycle engine is compared with a magneto from a four cylinder four stroke cycle engine it will be noted that the profile of the cam is different. If magnetos from engines with a different number of cylinders are compared both the cam profiles and the gear ratios between the distributor drive gear and the distributor will be different. Otherwise the magnetos will be identical. It is understood that the reference is for magnetos made by the same manufacturer. So that if a spare magneto is in the shop and the machine upon which that magneto is used falls off the line due to magneto trouble, just strip both the faulty magneto and the good spare of the parts that are not identical and install the cam, distributor drive gear, and distributor from the dead magneto in the good one and the machine will be back in a very short time. Then place the corresponding parts back into the dead magneto with the alignment as was noted when they were removed from the good magneto. This will make it much easier for the magneto repairman to restore the magneto to operating condition. This magneto will come back as a spare for the service intended for the magneto just used. Under normal conditions this would probably never be done; now with materials delayed and most repair shops loaded with work any idea that will move the actual horsepower hours nearer the desired horsepower hours is not only desirable but essential. In the event there is no one in the organization who feels that he knows enough about magnetos to attempt to perform the work outlined it is suggested that the mechanic in such an organization go to his magneto repairman for instructions.

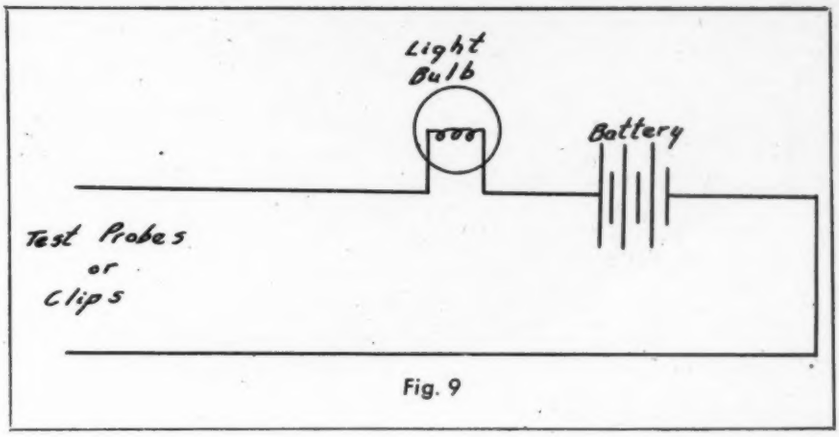


Fig. 9

Conclusion

In conclusion, be reminded that the function of the magneto is to deliver to the spark plug an electrical charge of sufficient power to ignite the mixture in the cylinder at the proper time. As noted, each of the simple parts of the magneto must function perfectly at the right time to assure the proper voltage. The magneto must be in time with the engine to assure that the current will reach the spark plug at the proper time. The high tension leads must be sufficiently insulated to assure that the current will reach the spark plug without loss and the spark plug must be in such condition as to assure that the current will ignite the charge in the cylinder. It is only when all these conditions are fulfilled that the magneto is functioning properly.

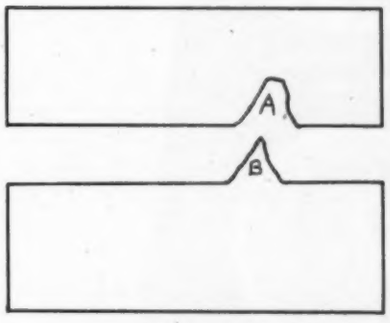
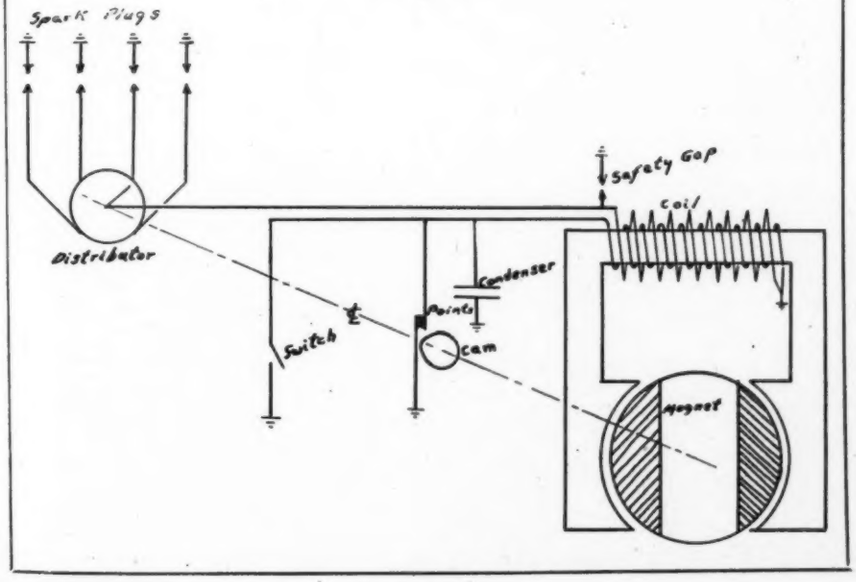


Fig. 10

Fig. 8



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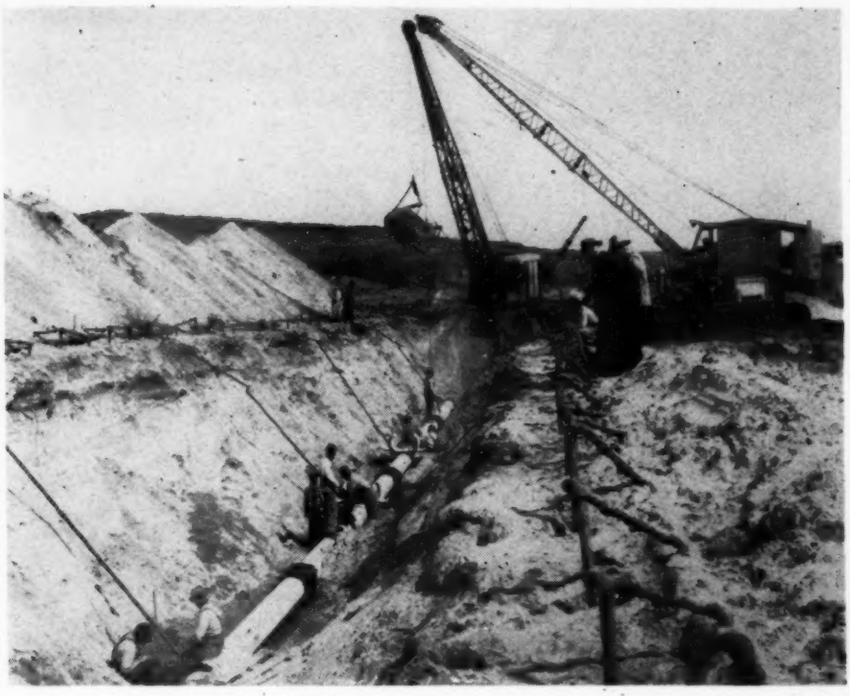


Major river crossings were dewatered by sandpointing and the pipe line trench dug with draglines

PETROLEUM ENGINEER Exclusive Feature

by

Frank H. Love

Managing Editor

Stanolind's West Texas-Oklahoma Line

☆ Construction features of new carrier, which will make available more crude oil to District 2 refineries

CONSTRUCTED to make available increased supplies of crude oil to refineries in District No. 2, Stanolind Pipe Line Company's 16-in. carrier from the Slaughter pool, Texas, to Drumright, Oklahoma, will be completed this month. Accelerated war demands and declining crude oil stocks prompted the Petroleum Administration for War and the War Production Board to approve the line, which will take oil from the Permian Basin, an area capable of greater production without the necessity of immediately drilling more wells.

The job was divided into five sections averaging about 75 miles each, and a complete laying gang or "spread" worked on each section. All sections were started between November 22 and December 26. Three contractors had one section each and a fourth contractor two of them. One of the first three contractors also had a separate job of installing the six important submarine river crossings. Exceptionally fast laying time has been accomplished despite set-backs caused by snow and rain.

In addition to the 385 miles of main line from West Texas to Drumright, 10 miles of 8-in. and 7 miles of 16-in. pipe were laid to connect with existing lines in the Wasson and Slaughter, Texas, areas.

Aided by a differential in altitude of approximately 2500 ft. between Slaughter field and Drumright, a station at Slaughter and a booster at

Lining up a section of pipe for welding

Lowering in line coated with asphaltmastic

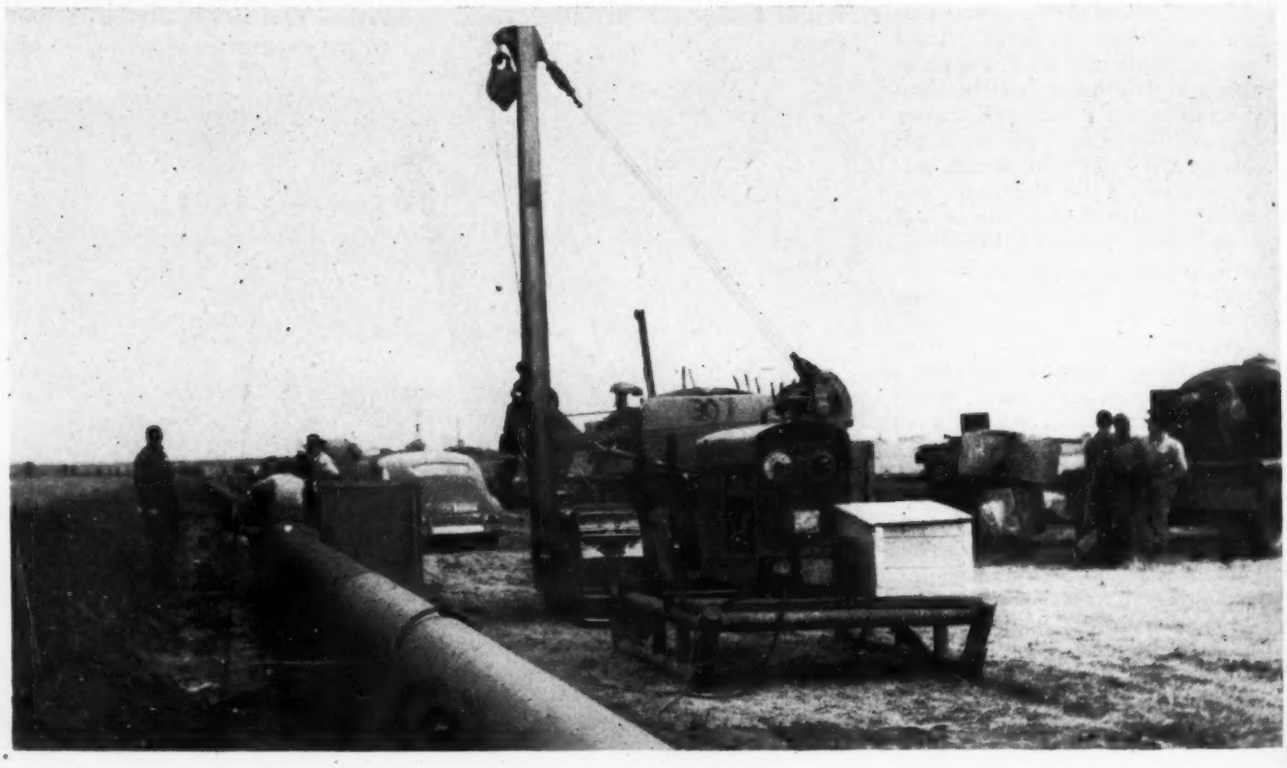
Bretch, about 10 miles south of Hobart, Oklahoma, each operating at 800-lb. pressure, will pump 65,000 bbl. of crude oil per day. At Drumright oil will be delivered into Stanolind's main line going to Whiting, Indiana, as well as into the lines of other major companies for transportation to refineries throughout the Midwest.

The right-of-way of the line traverses a terrain varying widely in its characteristics, from level plains to deep rocky canyons, and construction methods were adopted to cope with these varying conditions. Through the area consisting almost entirely of canyons and hills (a distance of approximately 75 miles) line pipe was coated with Somastic, an asphalt mastic material. This same coating also was used on river crossings. The remainder of the line was coated with petroleum asphalt and wrapped with asbestos felt. County roads, creek crossings, and suspected hot spots, were given a double coating and wrapping of the asphalt and felt. Railroad and main highway crossings were encased in 20-in. steel pipe.

Somastic coating was applied to the pipe in central yards and for this purpose two plants were established, one at Childress and the other at Roaring Springs, Texas. From these points the pipe was trucked to the 75-mile section beginning on the south side of the Prairie Dog Town Fork of Red River and extending southwest. Even in the case of the more distant river crossings the pipe was hauled by truck. In each instance trucks were padded to prevent damage to coating. When applying the coating in a central plant the pipe joints were coated only to within about 9 in. of each end. This gave welders in the field ample room to operate. After the welds were made a mold was clamped over the bare area and into it hot coating material tamped. Approximately one hour was required for the coating to set.

Prior to the application of asphalt coating and asbestos felt wrapper, the

Wooden shields were necessary to protect the welding arc from strong winds in the South Plains area of West Texas



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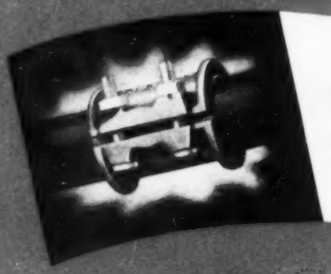

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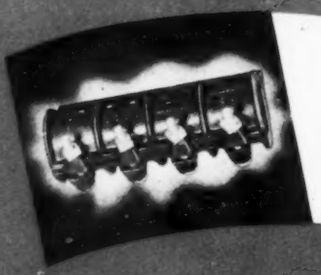

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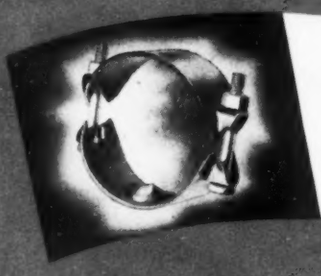

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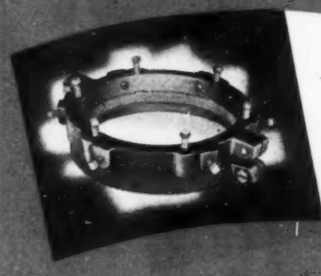

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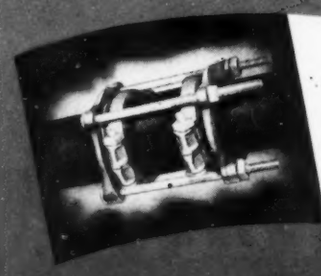

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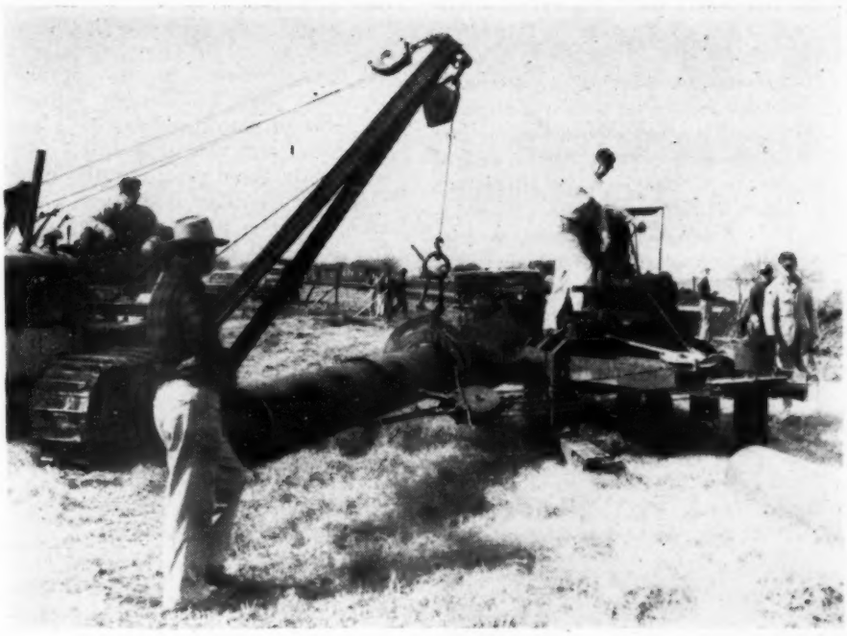

Pipe bending machines greatly aided speed of construction in rough and hilly country

pipe was cleaned and primed over the ditch by a traveling-type cleaning and priming machine. A $\frac{5}{32}$-in. coating and single wrapper were given except at railroad and creek crossings and through "hot" soils. In such instances by adjusting the head of the traveling-type coating and wrapping machine it was possible to apply double coating and wrap in a single operation. Only a minor change is required for double coating. Application of the hot material was at a temperature from 350 to 400°F.

As the pipe was coated and wrapped slack loops were left up, otherwise the line was lowered in immediately. To cool and harden the coating more quickly the line was sprayed with cool water behind the coating machine when the temperature was above freezing. To accomplish this a circular spray that fits around the line pipe was fashioned of ½-in. pipe and a tank wagon equipped with a pressure pump supplied the water.

River Crossings

Six major river crossings were laid. In addition to being coated with asphalt-mastic, heavier pipe, weighing 82.77 lb. per ft. and having a ½-in. wall thickness, was used. Clamps weighing 1400 lb. each were placed in the center of each joint of pipe, i.e. every 40 ft. The line was laid below the scour line of the river, approximately 16 ft. on an average, the trench being dug with a dragline after the sand had been dewatered. For purposes of dewatering a series of sand points were jetted into the bed of the river to a depth of about 2 to 5 ft. below the desired depth of the trench. The sand points were connected into main suction headers to which were connected pumping units. The water was thus drawn from the river bed and discharged into a ditch leading back into the river downstream from the crossing. River banks were excavated for several hundred feet to depths necessary to lay the pipe at the same elevation as in the bed of the river.

The rivers crossed, approximate location of the crossings, and number of feet of pipe laid, were as follows: North Pease, about 18 miles southwest of Childress, Texas, 900 ft. of pipe; Salt Fork of Red River, 10 miles northwest of Altus, Oklahoma, 5500 ft.; North Fork of Red River, 17 miles northeast of Altus, 5600 ft.; Washita, near Carnegie, Oklahoma, 400 ft. (this was the only river crossing not dewatered); South Canadian, 12 miles southwest of El Reno, Oklahoma, 4500 ft., and North Canadian, 6 miles east of El Reno, 1600 ft.

Instead of looping upstream to obtain sufficient slack, river crossings were laid in a zigzag course.

All river crossings were given an air test to 100 lb. per sq. in. for a period of 72 hours.

Welding

Because the pipe was high in manganese a change was made on three of the jobs in the procedure involved in joining the pipe by the electric arc method of welding, which resulted in an improved quality of welds. Three crews were employed, each running but one bead. In this manner it was possible to use the more experienced welders in the first and second crews where a flaw in the welds might weaken the entire joint. Also, this allowed enough time between the making of the second and third beads for the second bead to cool and clean up properly, resulting in a stronger weld.

In the South Plains area of West Texas wooden shields were used to protect the welding arc from the strong

To cool and harden coating more quickly the line was sprayed with water when the temperature was above freezing

and incessant winds, otherwise difficulty would have been experienced in flowing the weld metal properly.

In lining up for welding the stovepipe method was found most suitable for the working conditions.

Pipe Bending

Pipe bends were made cold, using a machine developed for that purpose. Design of this bending machine originally was begun for use on War Emergency Pipelines' 24-in. crude oil line. It was completed in time to be available only for the final stages of that project, but was used throughout the laying of WEP's 20-in. products line. Its use on the Stanolind line greatly aided the speed of construction in rough and hilly country.

The machine consists of a series of adjustable shoes that fit the contour of the pipe. After being placed in the machine the pipe is bent to the desired angle, power being provided either by a gasoline engine or tractor.

The machine was used both on bare pipe and on Somastic coated pipe. In the latter case, during cold weather, a limited amount of heat was applied with a butane torch to soften the coating just enough to prevent it from cracking. Average time required to make a bend was 6 min.

16" Pipe Line in West Texas

for

Stanolind Pipe Line Company

* *

SHARMAN & ALLEN

Pipe Line Contractors

536 Oil and Gas Building Houston, Texas

Gate Valves

Block valves have been installed at all river crossings. In most instances these are single installations, although at some crossings valves have been placed on each side of the river. Two valves have been placed at the Prairie Dog Town Fork of Red River, one on each side. This is at a point where the line is carried overhead on a highway bridge. Valves also have been installed on each bank of the Salt Fork of Red River. At the South Canadian River crossing a scraper trap has been placed on the south side and a gate valve on the north. All other river crossings have single valves. In addition to the scraper trap installation at the South Canadian River crossing mentioned, scraper trap junctions have been provided also at Floydada and Childress, Texas.

As is customary practice with Stanolind, a Polston-Hill nipple has been welded into the line on each side of the gate valves, providing a means of draining the line in event of a break or leak. By means of this arrangement the line can be drained from either direction by connecting a pump to the proper nipple.

Tankage

Tankage is being erected at 15 locations, consisting of thirteen 85,000-bbl., four 30,000-bbl., and ten 20,000-bbl. tanks. There are four tanks at Wasson and six tanks at Slaughter. The remaining tanks are being erected along the main line between Drumright and Whiting, Indiana, for handling West Texas crude oil. Secondhand plates have been used for approximately 95 per cent of the total steel tonnage required. To provide the material thirty 80,000-bbl. riveted tanks were dismantled at Casper, Wyoming, and re-erected as welded tanks. A discussion of this accomplishment is included elsewhere in this issue.*

Line Pipe

Line pipe is both of seamless and longitudinal weld construction. Weight of the pipe used on most of the main line is 42.05 lb. per ft. Heavier pipe is used on the discharge sides of the Slaughter and Bretch stations, being 47.67 lb. pipe for a distance of 15 miles at each station. As mentioned, pipe at river crossing weighs 82.77 lb. per ft.

Station Equipment

At the Slaughter station main pumping units consist of three motor driven centrifugal pumps that will be operated in series for a capacity of 65,000 bbl. per day. They are connected so any one may be operated singly or any two may be operated in series. Unit No. 1 is a

*See article by E. Palmer Shelton.

single-stage, 1750-r.p.m. pump, direct connected to a 150-hp. electric motor. Units No. 2 and No. 3 are two-stage, 3570-r.p.m. pumps, each direct connected to a 500-hp. electric motor.

The auxiliary suction pump at this station is a 10-in. by 18-in. horizontal duplex piston pump, steel chain driven by a 25-hp., 1165-r.p.m. electric motor. This pump is used for pulling field oil to the station to fill storage tanks and for evacuating station lines or transferring storage oil from and between station tanks.

The sump pump is a small vertical-type, two-stage centrifugal unit direct connected to a vertical-type explosion-proof electric motor with explosion-proof float switch for automatic operation. This unit is used for transferring drain oil from the underground sump to storage tanks.

At the Bretch station the main pumping units consist of two centrifugal pumps that will be operated in series or singly. In series they will handle 65,000 bbl. per day. Each pump is two-stage and is direct connected to a 3550-r.p.m., 500-hp. electric motor.

The auxiliary suction pump is a 2½-in. by 6-in. horizontal duplex unit and is V-belt driven by a 25-hp., 1165-r.p.m. electric motor. This pump is automatically operated through an explosionproof float switch on the oil sump tank. The main pump bearings discharge approximately 20 gal. per min. of crude oil through the pump bearings for cooling into the oil sump tank and this oil is picked up by the small suction pump and discharged into the outgoing stream at approximately 800-lb. pressure.

Pumping equipment at Slaughter and Bretch stations are connected to provide flexibility of operation. This provides for any one of the following pumping rates from Slaughter station to Drumright:

1. 44,000 bbl. per day.
2. 48,500 bbl. per day.
3. 51,000 bbl. per day.
4. 53,800 bbl. per day.
5. 58,000 bbl. per day.
6. 60,000 bbl. per day.
7. 64,000 bbl. per day.
8. 72,000 bbl. per day.

These pumping rates are based on summer operations. Electric power for driving the equipment is purchased. Stanolind Pipe Line Company personnel constructed the stations.

Contractors

Four contractors were in charge of the line work, Midwestern Engineers of Tulsa, Oklahoma, O. C. Whitaker Company of Fort Worth, Texas, I. C. Little of Dallas, Texas, and Sharman and Allen of Houston.

——— ☆ ☆ ☆ ———

OVER 25 YEARS
Continuous Pipe Line
EXPERIENCE

One of six river crossings built by O. C. Whitaker Co. on the 383-mile Stanolind 16-in. line from Drumright, Oklahoma, to Hockley County, Texas.

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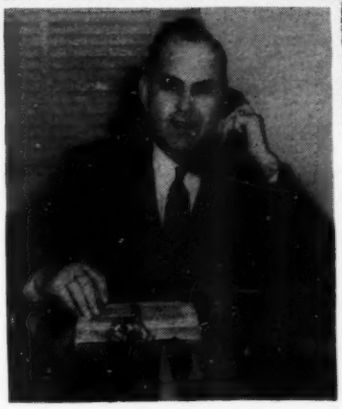
in pipe line department
of U. S. Armed Forces

Roy Clark
General Superintendent

G. Charles Childre
Finance Manager
and Engineer

EASTERN CONSTRUCTION COMPANY is now handling one of the toughest of pipe line assignments—a manifold distributing system of the War Emergency Pipe Lines, connecting with various refineries at Bayonne, New Jersey. The lines are just across the Hudson River within the shadow of New York City. This is the second W.E.P. contract, the first being the last section of the Little Big-Inch Line through New Jersey. The rapid progress made by this company on these projects is largely due to the new, modern, streamlined equipment which is the latest type available.

FOLKS WHO KNOW *Pipe Line* STRINGING



C. HOBSON DUNN

ERNEST C. DUNN
General Manager

MISS E. A. ANDERSON
Office Manager

ELLIS E. DUNN
Assistant General Manager

At right is shown Ernest C. Dunn and Ellis E. Dunn, who last year purchased interest and became partners in the C. Hobson Dunn Company. Both have been active in this company for the past twenty years.

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H. H. McAFEE
Superintendent

A. R. BAKER
Superintendent

These folks are only a few of the big C. Hobson Dunn organization which has permit authority to string pipe lines throughout the United States and District of Columbia. Equipment consists of the most modern and efficient type trucks, caterpillars and unloading cranes capable for use in stringing any size pipe lines, anywhere and at any time. Our record of performance is your assurance of getting an outstanding pipeline stringing job.

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Chief Mechanic in Charge of All Equipment

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Superintendent

E. R. RATHJEN
Superintendent

CLIFTON HAMMETT
Superintendent

L. L. ROWLAND
Superintendent

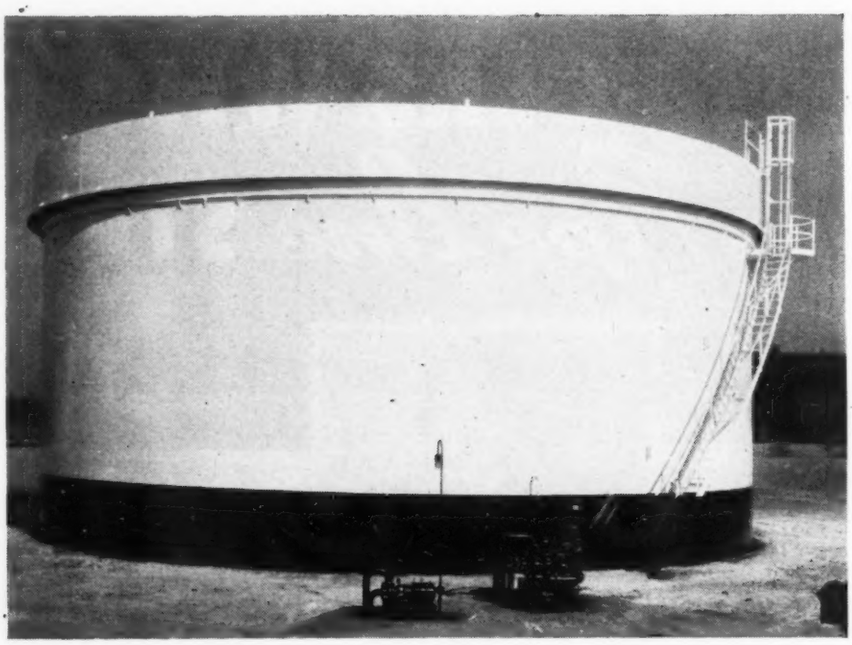
HUBERT E. TAYLOR
Superintendent

HERBERT G. TAYLOR
Superintendent

C. HOBSON DUNN Dallas, Texas

PIPE LINE STRINGERS

Expansion roof tank, 72 ft. diam., 34 ft. 9 in. high, roof lift 5 ft., storage capacity 25,000 bbl., expansion capacity 20,640 cu. ft.



PETROLEUM ENGINEER Exclusive Feature

by

H. J. D'Aragon

Conservation Engineer,
Graver Tank & Mfg. Co.

Protective Storage at Pipe Line Terminals

Conservation of petroleum by preventing evaporation losses is no longer a mere theory

LARGE losses due to evaporation from volatile petroleum products stored in conventional tanks with fixed roofs have been recognized and admitted by the industry for many years. Since the early days when storage tanks were covered with wooden roofs, petroleum engineers have conceded that such large losses exist and must be included in the cost of storage. At first, however, only a few of the more farsighted companies were willing to take any active steps toward decreasing evaporation losses; the majority looked upon these losses as a necessary evil inherent to the industry. Soon, however, as the full magnitude of such losses became apparent and the industry became aware of their importance, more companies devised saving methods. Today, the use of evaporation saving equipment in one form or another is accepted practice in storing volatile petroleum products at every point along the line, from the tank farm and refinery to the bulk station and consumer.

Tremendous progress has been made in recent years in perfecting the proper type of equipment to prevent evaporation loss under all conditions of storage. It is to be noted, however, that although most oil companies are anxious to protect their products efficiently, and do make use of the most up-to-date methods and equipment to attain that end, some have been satisfied with taking indifferent measures that insure small though reasonably quick returns on the money invested in equipment.

The tendency has been to look upon such savings in terms of dollars and cents only, and not to visualize them as actual barrels of product conserved out of a total volume, the greater portion of which was permitted to dissipate into the atmosphere through improper protection.

In a country such as ours, notorious in the past for its waste of natural resources, such a point of view is not surprising. We have been so accustomed to thinking in terms of endless reserves of raw materials, that only as a result of our finding ourselves engaged in a struggle for our very survival have we become conscious of the importance of conserving all our precious stocks and maintaining the quality of our petroleum products upon which so much depends.

In the future we will be less inclined to feel complacent in the knowledge that we have saved several thousands of dollars in a given storage period by installing evaporation saving equipment, without first satisfying ourselves that such savings approach the maximum to be expected from the proper use of modern methods and design.

This change in the national consciousness has resulted in a greater demand from petroleum men for all available reliable information on evaporation losses. During recent years much data have been published on the theory of evaporation; unfortunately however, little information has been available on the application of this theory to storage in field tanks under actual operating conditions. One finds still in use many rule of thumb assumptions for determining losses from storage tanks, some of which have been proved basically incorrect by reliable and conclusive tests.

Evaporation of volatile liquids such as gasoline follows certain definite fundamental physical laws. Gasoline is composed of hydrocarbons that boil at different temperatures. The lower their boiling point, the greater their tendency to change from the liquid to the gaseous state. If restricted in a closed container, they will exert a force known as vapor pressure, which is a measure of their tendency to vaporize.

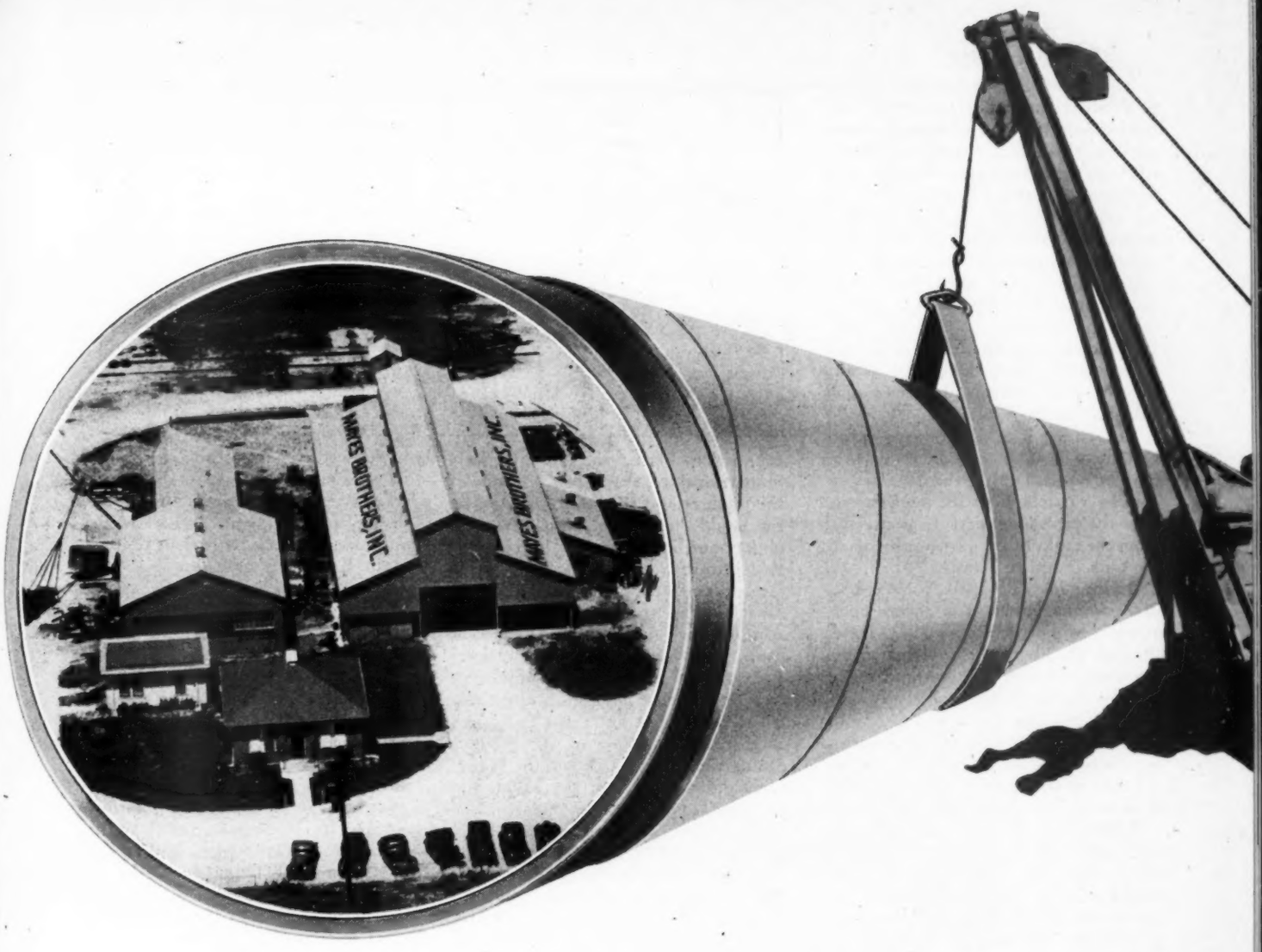
The highly volatile compounds or lighter fractions in gasoline possess the best qualities when measured by their effect on the performance of our modern, high compression motors. Loss of these fractions to the atmosphere through improper protection reduces the utility of the product as a motor fuel. The relation of its resulting physical deterioration, as evidenced by a lowering of volatility and octane rating, to its performance in a motor is as follows:

1. A decrease in vapor pressure affects ease of starting and lengthens warm-up period.

2. A rise in boiling point is responsible for sluggish response to full power acceleration.

3. A drop in octane number lowers its anti-knock quality.

It follows that any volumetric loss



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of product through evaporation is attended by a still greater depreciation in quality. This fact is often ignored when studying actual evaporation losses such as shown on Table 1 and Fig. 1, which are generally indicated as percentages of original total storage capacity. As a review, evaporation losses from the conventional storage tank with fixed (cone) roof, may be classified and described as follows:

Windage loss. The action of air currents entering the tank through a leaky roof or open vents and carrying off valuable vapors, is called windage.

Breathing loss. Daily temperature variations cause air to be drawn into the tank at night. During the day, this air absorbs vapor and as the temperature rises the air-vapor mixture is expelled from the tank. In completing this cycle, the tank is said to breathe.

Boiling loss. Products, such as natural gasoline, that boil at normal operating temperatures, sustain losses through the liberation of vapor within the body of the liquid in the form of bubbles that rise to the surface. This action occurs when the vapor pressure of the liquid, as influenced by the temperature, is equal to that of the atmosphere.

Losses in the above group are usually designated as standing losses.

Filling loss. When a cone roof tank is partially full of a volatile product, the space above the liquid contains vapor mixed with air in varying degrees of concentration. If additional product is pumped into the tank, the displaced air-vapor mixture is forced out through the vent.

An assumption widely used in computing expected evaporation losses, and one that has a reasonable theoretical foundation, is that the loss is directly proportional to the vapor pressure of the product and to the surface area of the liquid (horizontal cross-section of tank); but, in the face of latest available information derived from actual tests on tanks covering a wide range of capacities and made under actual operating conditions, this method must be considered unsatisfactory. The numerous variables, difficult if not impossible to estimate, that enter into any theoretical analysis of losses in a tank such as the vapor pressure of the product during the operating period, the "skin" surface temperature of the liquid, and the expected inventory or outage in the tank, render such an ambitious method impractical as well as generally inaccurate. The conclusion reached after careful consideration of much published data, based both on conscientious attempts to reconcile theory with practice and on actual operating results, is that reliable information based on physical results should always be used when available.

TABLE 1

Standing evaporation losses—motor gasoline

Losses per year from cone roof, gas-tight storage tanks equipped with conventional pressure and vacuum valves

Tank capacity, bbl.	Loss percent of capacity per year	Loss in gal. per year
1,500	5½	3,465
2,500	5	5,250
5,000	4½	9,450
10,000	4	16,800
15,000	3½	22,050
25,000	3½	36,750
37,500	3¼	51,198
55,000	3	69,300
80,000	2.6	87,400

The information given in Table 1 and Fig. 1 covering evaporation losses represents the average of results obtained through tests conducted by 14 large oil companies on numerous tanks representing a wide range of capacities and on products covering a full scale of Reid vapor pressures. These tests were made north of the Ohio River and cover all the seasons of the year. All tanks were gas-tight cone roof tanks equipped with the conventional pressure-vacuum relief valves.

Table 1 shows standing losses per year both as a percentage of total tank capacity and as a total volume in gallons. The tests on which these data are based were made during the summer months on motor gasolines of an average Reid vapor pressure of 9 lb. per sq. in., and during the winter months on products of not more than 12 lb. per sq. in. Reid vapor pressure.

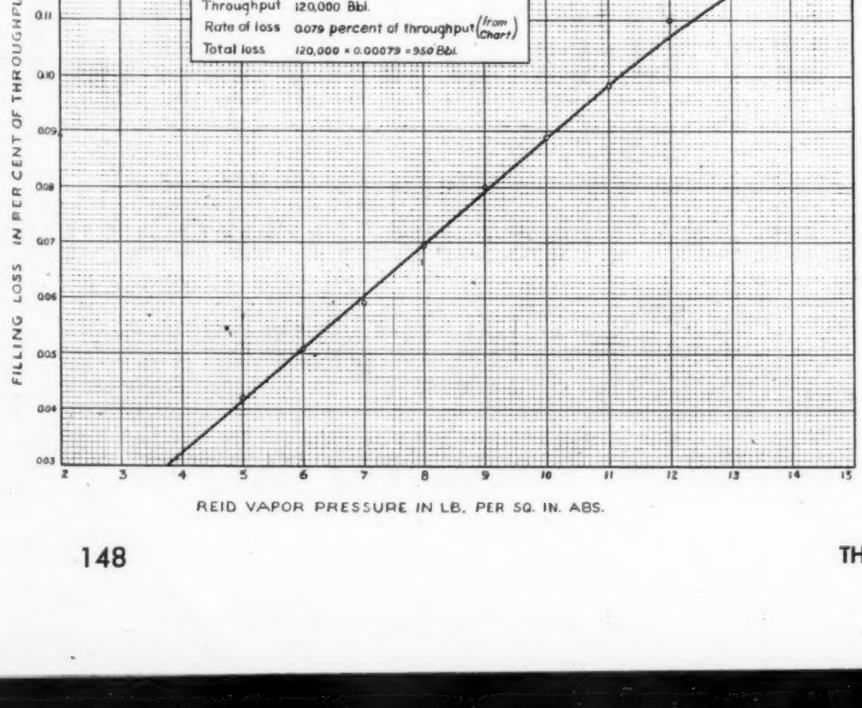
A study of this table shows an obvious relationship exists between the evaporation and the capacity of the tank; it is proportionately greater from small tanks than for the larger ones. The reason for this relationship becomes clear when we consider that the tests were conducted on tanks of standard economical sizes such as are normally used. Such a relationship would not be applicable to a tank having a ratio of diameter to height completely outside the realm of accepted, common engineering practice. Using these tabulated values, therefore, a curve may be platted that can be used safely to compute standing losses for tanks of intermediate capacities.

Filling losses from cone roof tanks in per cent of throughput are shown in Fig. 1. The curve is drawn through various points (small circles) established as a result of the conclusive tests, mentioned previously, on a widespread variety of products having different Reid vapor pressure.

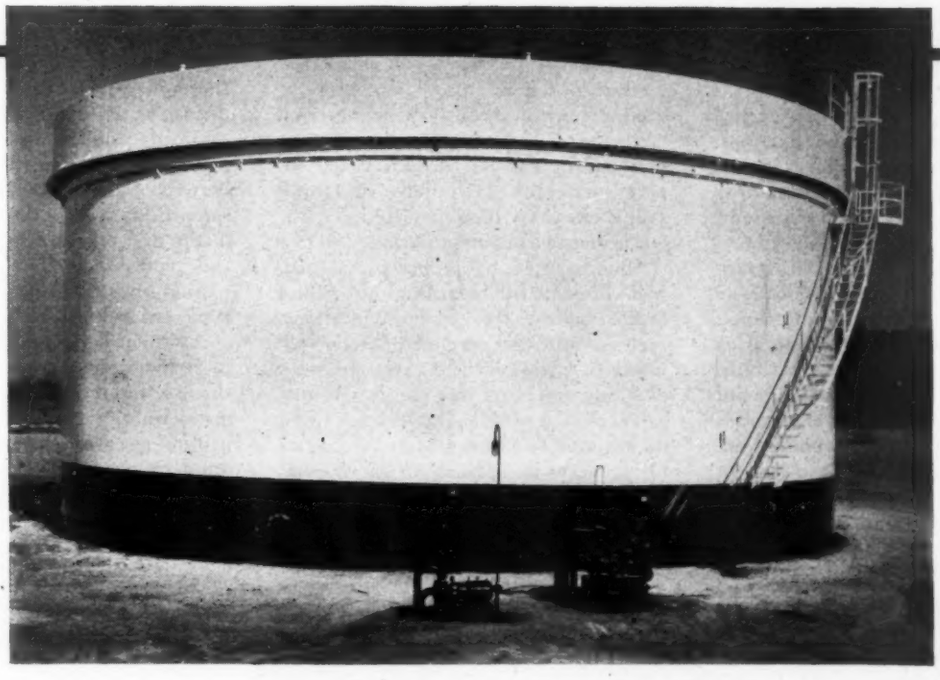
All the various classifications of evaporation losses can be prevented or materially reduced by the use of the proper equipment and operating methods, but the happy solution to the individual evaporation problem confronting the engineer, lies in his correct analysis of the factors involved as well as in his choice of equipment.

By far the greatest portion of the total evaporation losses generally occurring at a terminal for which provision must be made, are those caused by windage and breathing. Windage losses from tanks can be completely eliminated by the simple expedient of installing pressure and vacuum valves and ascertaining that all roof seams and connections are gas-tight. As the valves are usually set to operate at from ½ oz. to 2 oz. of partial vacuum and at a pressure of ½ oz. or more, depending on the product and the design of the tank, all cir-

Fig. 1. Showing filling losses in per cent of throughput from cone roof, gas-tight storage tanks equipped with conventional pressure and vacuum valves



How to maintain *Octane Rating* of gasoline in storage tanks



One of the major causes of a drop in octane number is evaporation, for with the escaping vapors go the light ends. It is a well known fact that a mere 4% evaporation loss means a drop of 3 points in octane number.

A Graver Expansion Roof Tank will prevent this drop by preventing evaporation loss. Instead of permitting the expanding vapors to be expelled, as they are with ordinary cone roof tanks, the Graver Expansion Roof rises, providing ample vapor space and holding all vapors within the tank. As they contract, the roof drops accordingly. Result—no loss of valuable vapors, and . . . no lowering of octane number.

Furthermore, it isn't necessary to equip all of your tanks with Graver Expansion Roofs. If these tanks are spaced reasonably close together, a number of them can be manifolded to a single Graver Expansion Roof Tank of suitable size and it will provide protection for the entire group.

At refineries and pipe line terminals all over the country, Graver Expansion Roof Tanks are effecting enormous savings and maintaining product quality at the same time, quickly paying for themselves. And they can do the same for you.

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culation of air between the vapor space and the exterior is eliminated.

Breathing losses from single units can be entirely eliminated by storing product in tanks equipped with variable space or expansion roofs. The variable vapor space in such tanks is to provide for the maximum expansion of vapors caused by daily changes in temperature.

Breathing losses may be reduced to some extent by employing various means of diminishing temperature variations within the tank, the most economical and relatively efficient of which is the use of reflecting or light colored paints on the roof or the tank.

There are other means of materially reducing tank temperatures such as the use of a "water top," or seal, carried over the tank by means of a flat roof, and the use of waterspray on the roof. Metal hoods or sunshades and insulating material have also been used with some degree of success. These methods, however, have not found favor in this country, as the results obtained do not seem to warrant expenditure or maintenance.

As the usual problem in evaporation confronting the engineer at a terminal or refinery is not one of single units but of several tanks, which may or may not carry the same volatile product, the problem of choosing the most efficient type of evaporation saving equipment is somewhat more complex. As is often the case, any proposed protective devices must include cone roof tanks that are already in existence.

By connecting the vapor spaces of several cone roof tanks to a gas reservoir or to the vapor space of one tank equipped with a variable space roof, evaporation losses can be reduced or eliminated at minimum cost. The vapor lines that lead from the tanks to the protective unit, in a closed system, permits the vapor to pass from one tank to another when breathing, or in the process of emptying or filling of the tanks. When total filling exceeds emptying, the gas reservoir or variable space roof provides expansion room from vapors that otherwise would be lost.

Closed or "balancing" systems may be used to store and protect a variety of products simultaneously. One major oil company, which has been using this method for the last several years, reports that tanks containing sweet and sour crudes have been manifolded without evidence of contamination.

Such systems, if properly designed, will eliminate all breathing and filling losses. Under all but extreme conditions, such as sometimes are encountered in refinery operations where the total rates of filling and emptying are greatly unbalanced, the additional reservoir capacity required to accommodate any excess filling losses in addition to the normal filling and breathing losses, can be provided with a minimum expenditure by equipping one or more tanks with variable space or expansion roofs. As a rule, terminal operations do not involve the use of more than one tank with expansion type roof to protect all storage.

The balancing action of closed systems and the elasticity obtained by the use of expansion type roofs are illustrated in Figs. 2 and 3.

Fig. 2 outlines a typical refinery unit, or battery of tanks, manifolded to one tank with variable space roof. Under ideal conditions, assuming no change in temperature, there would be no filling losses if the volume of crude received and that of products shipped in one day were equal.

It is obvious that the vapors displaced by the incoming crude would flow into the tanks vacated by the outgoing products. As this condition is rarely if ever attained, provision must be made for filling losses due to the daily difference between volume received and volume shipped, as well as for breathing losses due to daily changes in temperatures. In this typical example the necessary protection is provided by one expansion type roof as indicated.

A similar hook-up, modified to apply to terminal operations, is illustrated by the diagram in Fig. 3. With this type of installation, the size of the vapor expansion reservoir can be kept at a minimum by thoughtful scheduling of the filling and emptying operations.

Filling losses from single tanks may be efficiently eliminated by the use of a floating type roof. Such roofs rest directly on the liquid and operate on the principle that, with the theoretical elimination of the vapor space, no filling losses can occur.

As the use of such roofs is limited to single units and cannot take advantage of the balancing action of a closed system, protection against filling losses from a battery of tanks, such as shown on Fig. 3, could only be accomplished by installing a floating roof in each of the eight tanks shown.

Products, such as natural gasolines, that boil at atmospheric pressures under normal operating tank temperatures, should be stored in pressure tanks. Such tanks are designed to withstand a slightly higher pressure than that which must be built up in the vapor space in order to stop boiling of the liquid. It is usually sufficient to design pressure vessels for a working pressure of 3 lb. per sq. in. to protect the grades of natural gasolines in common use.

Conservation of petroleum by preventing evaporation losses is no longer confined to the realm of theory. Engineers have applied American ingenuity to this problem and have found an answer for every evaporation question.

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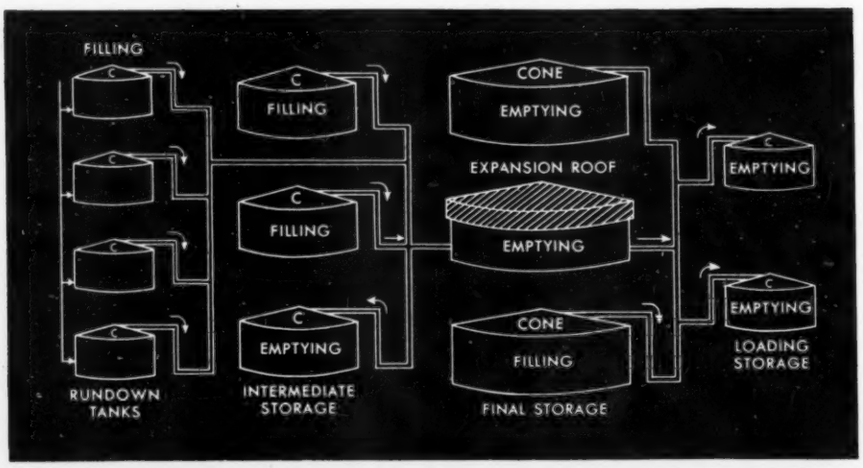

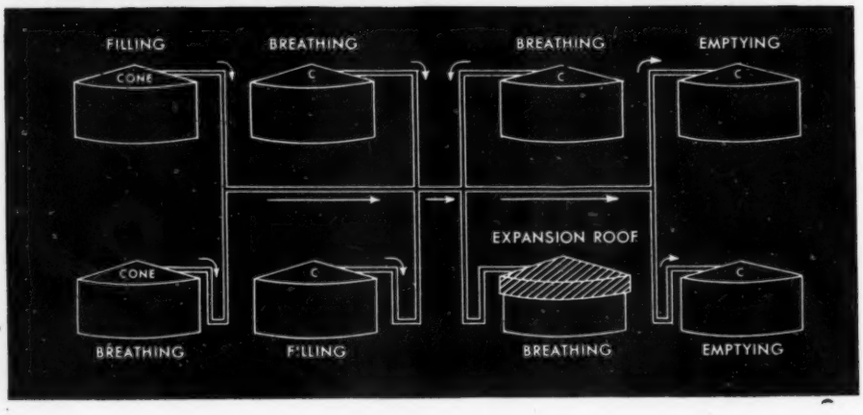

Fig. 2 (top). Typical refinery unit
Fig. 3 (bottom). Typical terminal installation

Pipe Line
P.615.222.

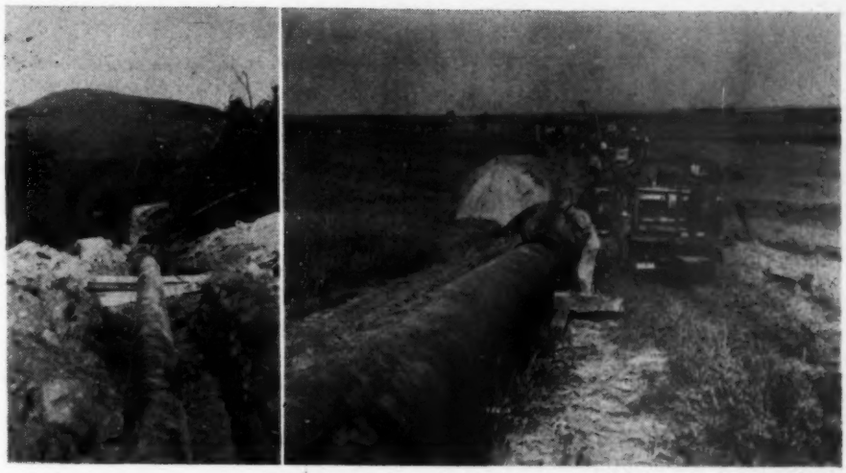

Fig. 1 (left)—Pipe line over mountainous country, ready to be lowered into ditch after stove pipe welding the sections together

Fig. 2 (right)—Construction of 10-in. gas line. Fairly flat terrain indicates use of roll welding

PETROLEUM ENGINEER Exclusive Feature

Arc Welding Pipe Lines

☆ Trends in methods employed during year are discussed

by C. M. Taylor

Vice President, The Lincoln Electric Company

IN MANY respects the past year has been similar to other recent years for pipe line contractors in that it was marked by the continued widespread use of the shielded arc process of welding for the construction of many additional miles of lines to carry the nation's oil and gas.

According to data supplied by some of the country's leading pipe line contractors, stove pipe and roll-welding methods, which have come into wide usage in recent years, predominated. The stove pipe method was used particularly where lines traversed rough or mountainous country (see Fig. 1), and roll-welding proved its efficiency over fairly smooth terrain, as indicated in Fig. 2.

On some jobs a combination of the two methods proved most effective.

It is also interesting to note that the larger sizes of pipe (up to 26-in. diam.) were preferred on most oil as well as gas lines. Only one oil line using the old 6-in. size for its entire 27-mile length was listed in a group of 10 typical pipe line construction jobs reported by one leading contractor.

The summary given in Table 1 concerns a few 1943 typical pipe line jobs but by no means covers the total mile-

Fig. 3—Stove pipe or position welding a 24-in. diameter oil line, using two operators, one on each side of joint

age of lines constructed during the year. Data were supplied by several leading contractors including H. C. Price Company, Midwestern Engineers, Williams Brothers Corporation, Bechtel-Dempsey-Price, and Smith Construction Company.

In stove pipe welding, the joints, which are usually plain end without liner, are position welded. After tacking, two welders, one on each side of the joint, as shown in Fig. 3, make the complete first bead, coming downward from the top.

When the terrain is fairly flat or rolling, the pipe is roll-welded and bell-hole welded. The helper turns the pipe on dollies with a chain wrench while the operator welds in a flat, downhand position.

A view of the construction operation (Fig. 4) on the 26-in. gas line for Cities Service Transportation and Chemical Company shows some interesting details of this project, which required a total of about 135,500 lb. of welding electrodes for the 240-mile length. A battery of 48 welding machines of 200 and 300-amp. capacity was employed on the line.

Recommended electrode sizes and average production per section per hour on pipe line construction is shown in Tables 2 and 3.

In the bell-hole type of welding, the pipe lengths are placed on timber skids over a trench large enough to permit the operator to apply the arc around the entire pipe. (See Fig. 5.) Smaller size electrodes—$\frac{5}{32}$ or $\frac{3}{16}$-in.—are used for these welds with amperage of 125 to 200.

Recommended amperage for various sizes of electrode is given in Table 4.

During the past year, pipe line recla-

TABLE 1

Some of the principal oil and gas pipe lines arc welded in 1943

Owner	Location	Length in miles	Pipe size, in.	Type of construction	Use
War Emergency Pipelines, Inc. ("Big Inch")	Longview, Texas, to Phoenixville, Pennsylvania	1253	24	Solid welded—stove pipe and roll welded	Oil
War Emergency Pipelines, Inc. (auxiliary to "Big Inch")	Phoenixville, Pennsylvania, to Linden, New Jersey	86	20	Stove pipe and roll welded	Oil
	Phoenixville, Pennsylvania, Philadelphia, Pennsylvania	37	20, 16 and 14	Stove pipe and roll welded	Oil
War Emergency Pipelines, Inc.	In Ohio	80	20	Solid welded—stove pipe	Oil
Leonard Pipe Line Company	Reed City, Michigan, to Marion, Michigan	27	6	Solid welded—stove pipe	Oil
Simrall Pipe Line Company	Near Reed City, Michigan	22	6 and 8	Solid welded—stove pipe	Oil
Panhandle Eastern Pipe Line Company	Loops in Kansas	180	26	Welded and coupled—roll weld	Gas
West Michigan Consumers Gas Company	Reed City, Michigan, to Muskegon, Michigan	60	8	Solid welded—stove pipe	Gas
Sinclair Pipe Line Company	Near Lexington, Missouri	30	8	Solid welded—roll weld	Oil
Cities Service Transportation and Chemical Company	Guymon, Oklahoma, to Blackwell, Oklahoma	240	26	Solid welded—roll weld	Gas
Zenith Gas System	Near Alva, Oklahoma	12	6 and 8	Solid welded—stove pipe	Gas
Ohio Oil Company	Rockford, Indiana, to Monroe, Ohio	12	10	Solid welded—stove pipe	Oil

TABLE 2

Recommended sizes of electrode for pipe line welding

Size, in.	Roll welding without back-up ring			Roll welding with back-up ring		Position welding without back-up ring, stove pipe or tie in method		
	Stringer bead, in.	Second bead, in.	Third bead, in.	Stringer bead, in.	Second bead, in.	Stringer bead, in.	Second bead, in.	Third bead, in.
6	5/32	3/16	1/4	5/32 or 7/32	1/4	5/32	5/32 or 3/16	3/16
8	5/32 or 3/16	3/16 or 1/4	1/4	7/32 or 1/4	1/4	5/32 or 3/16	5/32 or 3/16	3/16
10	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16	1/4 or 5/16	5/16 or 3/8	5/32 or 3/16	5/32 or 3/16	3/16
12	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16	1/4 or 5/16	5/16 or 3/8	5/32 or 3/16	5/32 or 3/16	3/16
14	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16	5/16	5/16 or 3/8	5/32 or 3/16	5/32 or 3/16	3/16
16	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16	5/16	5/16 or 3/8	5/32 or 3/16	5/32 or 3/16	3/16
18	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16	5/16	5/16 or 3/8	5/32 or 3/16	5/32 or 3/16	3/16
20	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16	5/16	5/16 or 3/8	5/32 or 3/16	5/32 or 3/16	3/16
22	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16	5/16	5/16 or 3/8	5/32 or 3/16	5/32 or 3/16	3/16
24	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16	5/16	5/16 or 3/8	5/32 or 3/16	5/32 or 3/16	3/16
26	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16	5/16	5/16 or 3/8	5/32 or 3/16	5/32 or 3/16	3/16

Position welding with back-up ring: Use 3/16-in. rod for all beads on all sizes of pipe.

NOTE: In above table size of electrode for first bead depends upon spacing.
Size of electrode for second and last beads depends upon thickness of pipe.
Use 5/32-in. electrode on additional beads when necessary.

Fig. 4—Applying corrosion-resisting coating to a welded 26-in. gas line at Cimarron River crossing

Fig. 5—Applying a bead all the way around gas pipe line in bell-hole type of welding

Illustrated Cities Service Transportation & Chemical Company project, a joint venture of
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During the war our entire personnel and facilities have been at the disposal of War Projects wherever they were needed. During 1943 H. C. PRICE CO. and associated Companies have constructed 2,200 miles of pipe lines which included all or portions of the following major projects.

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PIPE LINE AND ELECTRIC WELDING CONTRACTORS

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TABLE 3
Average speeds for shielded arc welding

Size, in.	Roll welding without back-up ring	Roll welding with back-up ring	Position welding without back-up ring
	Average welds per hour	Average welds per hour	(After first bead run by tackers) Average welds per hour
6	6.0	7.0	5.0
8	5.5	6.5	4.0
10	4.0	5.0	3.0
12	3.0	4.5	2.0
14	2.75	4.0	...
16	2.5	3.5	...
18	2.4	3.25	...
20	2.25	3.2	...
22	2.1	3.1	...
24	2.0	3.0	...
26	1.8	2.5	...

mation has come in for a great deal of attention due principally to the necessity for conserving materials.

A typical case of this type of work is shown in Figs. 6 and 7. Here, a 30-year-old, unused gas line was dug up and used to replace corroded sections of an old oil line. Fig. 6 shows an operator using a rotary flame cutting fixture to cut off threaded sections of old pipe at about a 30° angle.

Fig. 7 shows the operator applying the stringer bead with $\frac{5}{32}$-in. electrode after ends of pipe had been properly positioned with alignment fixture and tacked at four points.

The third and final bead is bell-hole welded. File and wire brush are used to remove slag from previous weld.

One of several other interesting pipe line maintenance jobs, as reported by one contractor, included the installation of 820 welding sleeves on the 6-in. main line of the Illinois Northern Utilities. On this line new sleeves, or collar sections, were welded all the way around the worn portions. The new sections were installed with the line under pressure, using two beads to effect a leakproof joint.

The most notable pipe line construction job of the year was unquestionably that of the much publicized "Big Inch," largest project of its kind in the world. With a length of 1251 miles traversing 9 states, this huge line was completed in 360 days over difficult terrain and under adverse weather conditions. An indication of the importance of this line is evident when comparing the total mileage saved in transportation. Previously, the oil was piped to Gulf Coast shipping points and transported by tanker to New Jersey, a distance of 2085 miles, as compared to the present 1339 miles via the "Big Inch," a saving of 646 miles.

The "Big Inch" is of 24-in. diameter pipe with a wall thickness of $\frac{3}{8}$-in. and is in 50-ft. sections. The trend toward welding without the use of back-up rings, even on such larger sizes of pipe, was evidenced in this large construction job, and partially accounts for the fact that this practice has almost disappeared in present day pipe line construction. Elimination of back-up rings is a definite advantage in that it reduces installation cost and does not retard the flow of oil or gas through the line.

Effective results were obtained by combining the increasingly popular stove pipe method of welding with the firing-line (roll-welding) method. Three sections of pipe were first lined up, tack-welded, then roll-welded. The first complete weld is made with $\frac{3}{16}$-in. general purpose electrode for mild steel, with the welder set at 200 amp. For the second pass, the same type electrode in the $\frac{1}{4}$-in. size is used, with 325 amp. The joint is then finish-welded using a $\frac{5}{16}$-in. size electrode.

Tractors carry the three welded pipe sections to the end of the line where they are lined up and clamped as shown in Fig. 2. The pipe is then bell-hole welded, two welders working simultaneously on both sides of the joint, making a complete bead, each welder working downward from the top.

In particularly rough terrain, the bell-hole method is used exclusively, one 50-ft. section of pipe at a time being welded to the end of the line.

TABLE 4
Recommended amperage and voltage for various sizes of rod

Size rod, in.	Amperage	Voltage
Roll welding		
$\frac{1}{8}$	100–150	30–40
$\frac{5}{32}$	125–200	30–40
$\frac{3}{16}$	150–225	30–40
$\frac{7}{32}$	175–300	30–40
$\frac{1}{4}$	200–325	30–40
$\frac{5}{16}$	250–400	30–40
$\frac{3}{8}$	350–500	30–40
Position welding		
$\frac{1}{8}$	100–150	25–40
$\frac{5}{32}$	125–200	25–40
$\frac{3}{16}$	125–200	25–40

☆ ☆ ☆

Fig. 6—Flame cutting section of old gas line prior to relaying and welding in the sections

Fig. 7—Applying stringer bead on pipe section after reclaiming to replace corroded sections of oil line

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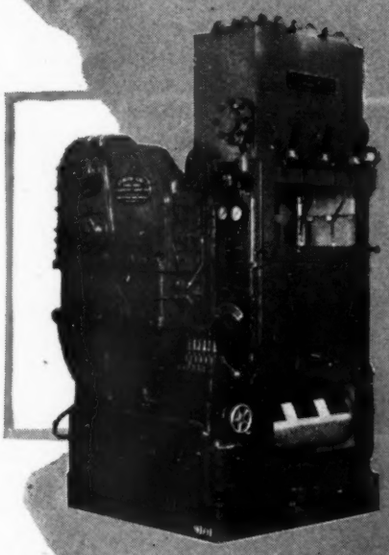
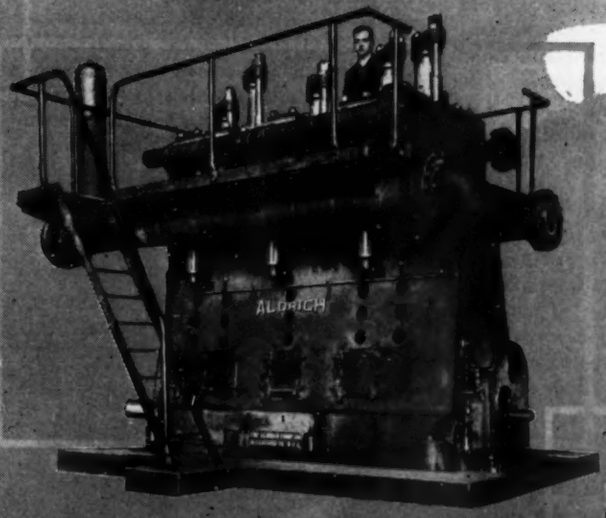


(Above) A special type of Aldrich-Groff "Powr-Savr" Constant Speed Variable Delivery Pump. This unit is driven by a 100 h.p. motor and is designed for butane or gasoline pipe line service. Other sizes available for process charging and other refining services.



(Right) This 750 h.p. inverted quintuplex pump is designed for direct coupling to engine. This unit is made for crude oil pipe line service and is equipped with Aldrich Patented "Kosmos" Porcelain Plungers.

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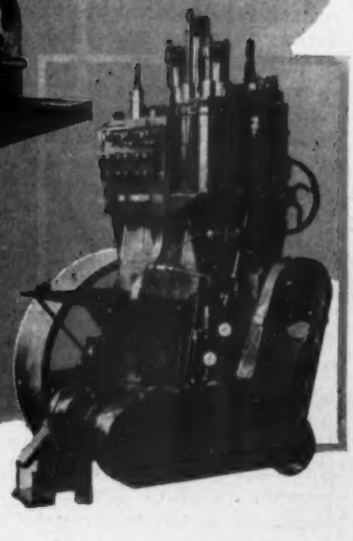

A special central hydraulic surface pump for belt drive to engine. This unit incorporates many features such as built-in by-pass and relief valves, suction booster pump, chemical feed pump and thermostatic control for lubricating oil pressure.

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P 624.5

Conditioning Station Cooling Water

PETROLEUM ENGINEER Exclusive

☆ A discussion of basic principles that are important to efficient station operation

by E. G. Hammerschmidt, Chief Chemist, Texoma Natural Gas Company

ALL water conditioning may be considered a form of preventive medicine; something you do and pay for to avoid costly and unpleasant consequences. Cooling water problems are interrelated with several other problems such as engine lubrication and combustion characteristics, in that any one or a combination of several of these factors may cause engine wear, shutdowns, and overhaul. Recent improvements in wear records on our system are, in a large measure, reflected by corresponding improvements in the abovementioned factors. Some of these improvements were made simultaneously and it is therefore difficult to evaluate the particular improvements that may accrue because of better water conditions. However, the writer is of the opinion that the water conditioning factor is one of the more important factors that govern uninterrupted operations.

This article discusses and explains basic principles of conditioning water for compressor station use that are not fully understood by some plant operators, but which, nevertheless, have an important bearing on operations. The substance of the article is based on material prepared and presented by the writer before company superintendents and foremen.

Scale Deposition

The term "water softening" should not be confused with "water conditioning." Water is treated or conditioned for the purpose of preventing scale deposition on heat transfer surfaces in the engines and on the cooling coils. It does not necessarily follow that the water must be "soft" to accomplish this purpose nor is it true that soft water will stop all scale deposition. In other words, the hardness of a water is not in itself a criterion of the scaling tendency of the water. The amount of hardness that can be held in solution in the cooling water is dependent upon four other factors, e.g., the total alkalinity, the pH, the temperature, and, to a lesser extent, the total dissolved solids. These four factors place a limit on the maximum hardness that can be held in solution. At all stations using the sodium zeolite treaters, this limit is reached when the hardness approaches 26 p.p.m., despite the fact that 125 to 325 p.p.m. of hardness have been removed from the original raw waters.

Slime deposits are of great importance in the heat transfer equipment. These deposits may sometimes be the result of algae accumulations only, but usually they are comparatively rich in bacteria, protozoa, and fungi as well. A slime deposit differs from a purely algal growth, in that it is denser, more gelatinous, and usually more tightly adherent to the surface affected. These deposits usually entrap large amounts of organic and inorganic debris, including air-borne sands and dirt as well as suspensions of scale formers, such as calcium and magnesium carbonates.

Water Conditioning

Softening. After our raw waters have been softened and aerated in the cooling towers, the pH is usually greater than the raw water. Furthermore, as the water is recirculated and becomes more concentrated, the alkalinity increases and the chemical character of the water changes somewhat (due possibly to the action of hot heat transfer surfaces)* so that a further increase in pH results. Both of these effects reduce the amount of hardness that can be held in solution, resulting in a balanced system water of about 26 p.p.m. hardness as indicated above. If no other control is exerted on the system water, it will reach the peak hardness of 26 p.p.m. and maintain this hardness by depositing scale on heat transfer surfaces. Our company's present method of preventing scale formation is by means of controlled blowdown of system water so that sufficient make-up water can be added to maintain the system water in chemical balance. It can be shown that the required amount of blowdown depends upon the total evaporation of system water and upon the residual hardness in the make-up water. Thus:

$$C = \frac{A + B}{A}$$

Where:

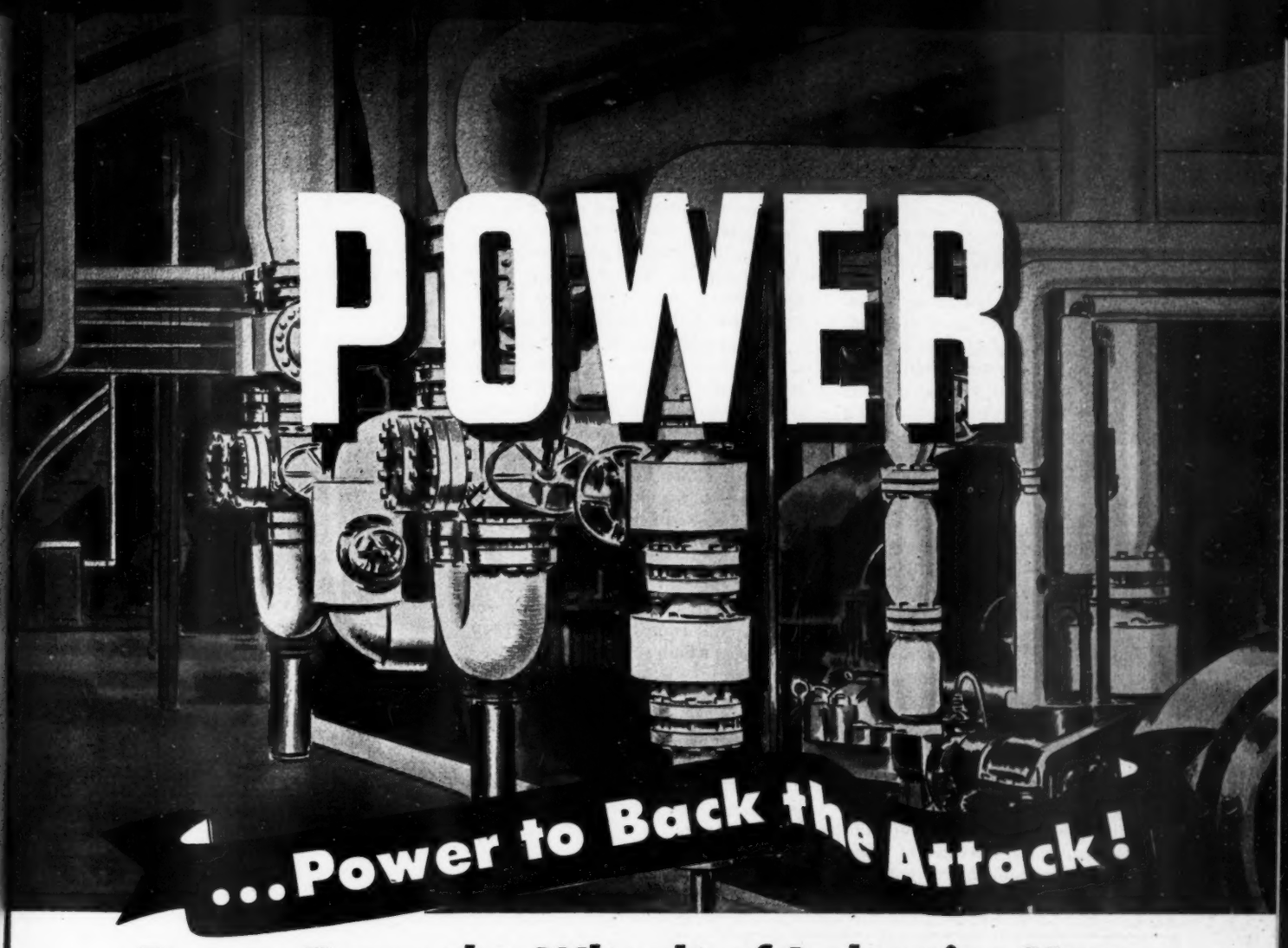
C = number of concentrations,
B = gal. evaporated per day, and
A = gal. blowdown per day.

The amount of daily evaporation, B, is virtually constant at 50,000 gal. when four units are in operation. The number of concentrations, C, is dependent upon the hardness of make-up and of system water. As system water has a constant hardness of about 26 p.p.m., the number of concentrations, C, can change only when the hardness of the make-up water changes. For example, if the make-up water has a hardness of 4 p.p.m., the number of concentrations, C, will be $\frac{26}{4} = 6.5$. Substituting in the preceding equation, we have $6.5 = \frac{A + 50{,}000}{A}$, and solving for A, we find the required blowdown to be 9100 gal. per day. In like manner, if the make-up water has a hardness of 8 p.p.m., the blowdown must be increased to 22,500

TABLE I

Station number	Period covered	Total concentrations	Hardness concentrations	Difference	Average scale conditions during the period
21*	Sept. 1942 to Feb. 1943..	5.8	7.9	−2.1	Nearly all scale loosened or gone entirely. Bad mud condition.
22†	Oct. 1942 to Feb. 1943...	3.0	2.2	0.8	No scale up to December, 1942.
2‡	June to Nov. 1942.....	3.0	1.8	1.2	Little scale. Loose.
3‡	May to Nov. 1942.....	4.4	1.5	2.9	Scale in exhaust valve casings, power heads and cylinder jackets. Descaled with acid.
4‡	Sept. to Nov. 1942.....	2.3	3.2	−0.9	System was badly scaled-up in July. Some scale build-up in cylinder jackets.
5‡	November 1942.....	2.3	2.0	0.3	Very little scale. 1½-in. mud.
6‡	June to Nov. 1942.....	2.0	1.4	0.6	Little scale. No deposition indicated.
7°	Dec. 1942 to Jan. 1943...	2.2	1.8	0.4	Slight scale. Some loose scale.
8*	June 1941 to Nov. 1942..	1.8	1.7	0.1	½-in. scale changed from hard to soft scale with loosening during this period.
9†	Feb. to Nov. 1942.....	2.7	2.3	0.4	No scale at all.
10‡	April to Nov. 1942.....	5.2	1.7	3.5	Had to descale with acid.

*Carbonaceous hydrogen exchanger with zeolite sodium exchanger.
†Lime followed by zeolite sodium exchanger.
‡Zeolite sodium exchanger.
°Carbonaceous sodium exchanger.
*Lime—soda—sodium aluminate.



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gal. per day, and if the make-up water hardness is 16 p.p.m., the blowdown must be increased to 80,000 gal. per day. The importance of operating the water softeners for a minimum effluent hardness is readily apparent from the above examples.

Slime control. The softening process has little, if any, effect upon slime deposits and the control of these deposits is another phase of water conditioning. The most economical method of continuous and efficient slime control is by chemical means, which includes treatment by chlorine, chloramine, copper sulphate, oxidizing agents, such as potassium permanganate, and various kinds of organic chemicals of which sodium pentachlorophenate is an outstanding example. Chlorine possesses several advantages as a toxic agent for the control of slime. Its toxicity is remarkably high, being equalled by few other materials; the maintenance of 0.5 p.p.m. residual will kill most species. It acts quickly. Simple chemical test may be used for control purposes. Used in correct dosage, it causes no corrosion of engineering materials, although in concentrated form it is destructive to most metals. It is readily available at a reasonable price. The volatility of chlorine is a disadvantage because of possible loss by aeration in the cooling towers. Another disadvantage is the rapid dissipation of its germicidal efficiency. Recent developments in the paper and pulp industry show that chloramines are more economical and more effective than chlorine alone. When the present shortage of ammonia disappears after the war, present chlorine treating plants can probably be converted to chloramine plants with very few changes.

The proper amount of chlorination may vary at different locations. Some forms of slime seem to build up a resistance to small chlorine residuals. Cases of this kind are usually controlled by relatively heavy dosages over a short period of time. The most economical and effective manner of chlorine injection can best be determined by experiment at each installation.

Velocity and Temperature

J. M. Krappe, carrying out a research project at Purdue University in 1940, found that a high velocity of water over heat transfer surfaces reduced the formation of scale at these points. He also found that a rapid increase in scale formation occurred when the temperature of the water rose from 140 to 180°F. These findings are being corroborated by our own observations at several compressor stations.

Interpretation of Tests

The soap hardness test is the most important test that we are now using for control work at all stations. Hardness in water is defined as that characteristic in water which destroys the property of soap that forms a lather. It should be remembered that a hardness determination is not a direct measure of the calcium and magnesium salts although it does give a good indication of the amount of these salts present, due to the fact that it is chiefly these salts that destroy the ability of soap to form a lather. The presence of free mineral acid in a water will consume soap. The presence of carbon dioxide and certain sodium salts together with pH values may also affect the hardness test so that some variation in hardness results may be expected with different waters even though these waters might contain identical quantities of scale-forming salts. The soap hardness test is therefore not a perfect test for control purposes, but when its deficiencies are recognized, it can still be made a very useful as well as a simple test.

The chloride determination is also a very useful test. It so happens that there are only three insoluble chlorides, e.g., silver, lead, and mercury, none of which are likely to be encountered in water conditioning. Such a condition provides assurance that no chlorides will be precipitated out of solution in the form of insoluble substances and because of this

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fact we can procure information on the total concentration being maintained in the system water. The number of concentrations is obtained simply by dividing the chlorides in the system water by the chlorides in the make-up water.

The chloride test may become unreliable when we are chlorinating the system water for slime control because chlorine reacts with the slime to form a soluble chloride, thereby giving an abnormally high chloride test that cannot be used for comparison with make-up water. Sulphate tests are usually substituted for chloride tests when there is interference with the chloride test but the sulphate test is not readily adaptable for control work by the plant operator, so we are using the next best test, which is the simple alkalinity determination. The chloride test, which is the more reliable test, should be used in preference to the alkalinity test when possible.

Theoretically, the system water is in chemical balance when the number of concentrations of chlorides (or alkalinity) is the same as the number of concentrations of soap hardness. Likewise, if the hardness concentration is less than the chloride concentration, precipitation of "scale formers" is indicated, and conversely, if the hardness concentration is greater than the chloride concentration, dissolving of scale is indicated. Due to the shortcomings of the control tests as discussed above, actual results will show some deviation from the theoretical behavior. A good idea can be obtained regarding the magnitude of this deviation by comparing the number of concentrations with the actual scale conditions as found by inspection of various units at all stations. These results have been tabulated in Table 1. The number of concentrations in the table represent the average of all available analyses during the period when inspections were being conducted.

According to the concentrations, station No. 10 shows the greatest scale forming tendency; e.g., a difference of 3.5 between the total concentration and hardness concentration. This is in agreement with the compressor station weekly report, which stated that acid descaling was required at station No. 10 during this period. Station No. 3 also shows scale-forming tendencies with a difference of 2.9 between total and hardness concentrations. This again checks with observed results, which show that scale was present in exhaust valve casings, power head, and cylinder jackets, and the Cooper units had to be descaled with acid. Station No. 2 indicates scale-forming tendencies with a difference of 1.2 between total and hardness concentrations. This does not check with visual observations which show that little scale is present. Station No. 22 indicates scaling, with a difference of 0.8 between total and hardness concentrations, although observed results show no scale formation up to December 8, 1942. The other stations (except No. 4) have little scale and the difference in concentrations is 0.6 or less. It therefore seems reasonable to conclude that no scaling troubles will occur if the difference between the total and hardness concentrations is not greater than 0.6.

The concentrations at station No. 4 indicate that scale is being dissolved but the inspection shows scale build-up in the engines. This is probably due to the fact that station No. 4 was badly scaled-up just before the period under consideration and when the dumping schedule was increased, scale was dissolved in the cool parts of the system, became supersaturated, and redeposited in the hot parts again. This condition is gradually improving, as the excess scale is being removed from the system.

The concentrations at station No. 21 indicate that scale is being dissolved, the hardness concentration being 2.1 greater than the total concentration. This condition has existed since the installation of the Zeo-Karb H water softener. It is due to a lowering in alkalinity, pH and the presence of some free carbon dioxide in this water.

——☆☆☆——

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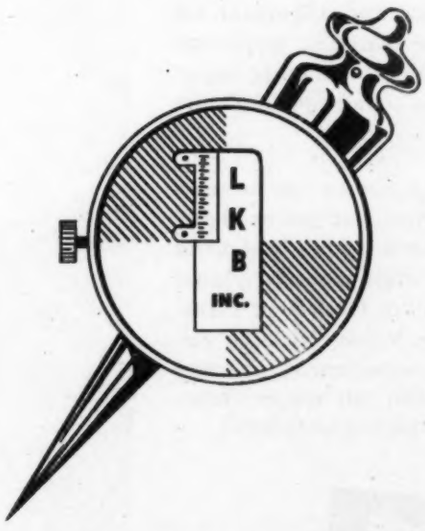

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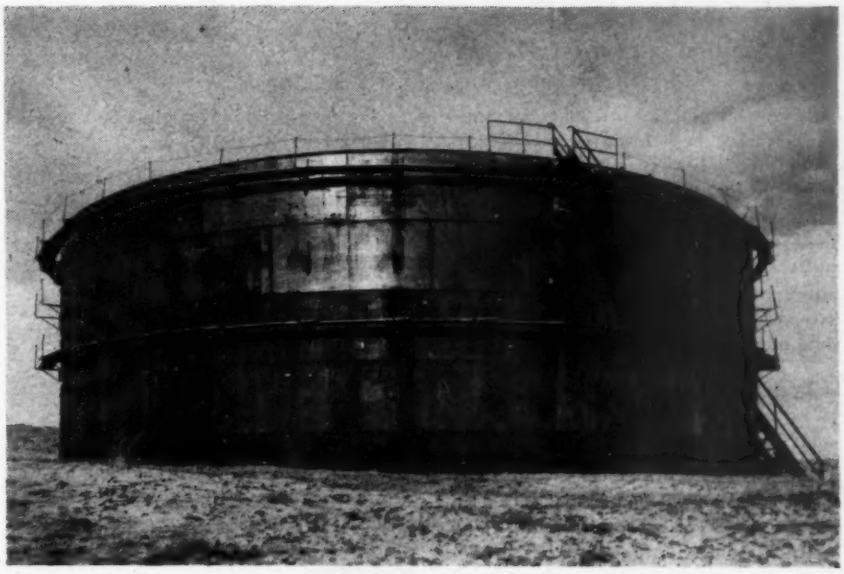


An 80,000-bbl. tank ready for dismantling. The lines where the plates are to be burned have been marked on the shell and the scaffolding is in place for cutting off the top angle

by
E. Palmer Shelton
Engineer, Chicago
Bridge & Iron Company

Minimum of Essential Materials Used in Tankage Installations

Dismantled and re-erected tanks provide 95 per cent of steel tonnage at 15 locations

EARLY in 1943 studies made by the Petroleum Industry War Council indicated that District No. 2, comprising 15 states from Michigan and Ohio on the east, Tennessee and Oklahoma on the south, and Kansas, Nebraska, and the Dakotas on the north, would be called upon to refine an increasing amount of crude oil in order to supply essential war needs. On the other hand, District No. 2 was facing a decreasing crude supply. Well recognized was the additional fact that crude storage inventories should not be allowed to decline materially in order to protect adequately war demands in that area.

Crude oil pipe lines from the Mid-Continent area had been operating at full capacity for more than a year despite declining production. This was done by withdrawing crude oil from storage in the Mid-Continent area and increasing shipments by pipe lines north from the Gulf Coast of Texas. Crude oil stocks were rapidly being exhausted, Mid-Continent production continued to decline, and increased shipments from the Gulf Coast were not justified. Present and potential Gulf Coast production was required for war plants then in operation or under construction. On the other hand, West Texas had large reserves available for production without the necessity of drilling additional wells.

Line Approved

To make West Texas crude oil from the Slaughter and Wasson pools available to refineries in District No. 2, the Stanolind Pipe Line Company laid plans, with the approval of the Petroleum Administration for War and the War Production Board, to build a pipe line from these fields to connect with their existing facilities at Cushing and Drumright, Oklahoma. In addition to connecting to the Stanolind Pipe Line Company's main line to District No. 2, the new line can deliver oil at Drumright or Cushing to the Texas, Texas-Empire, Shell, Empire, Gulf, Sinclair, Oklahoma, Magnolia, Standish, Mid-Continent, Tide Water, and Continental pipe lines.

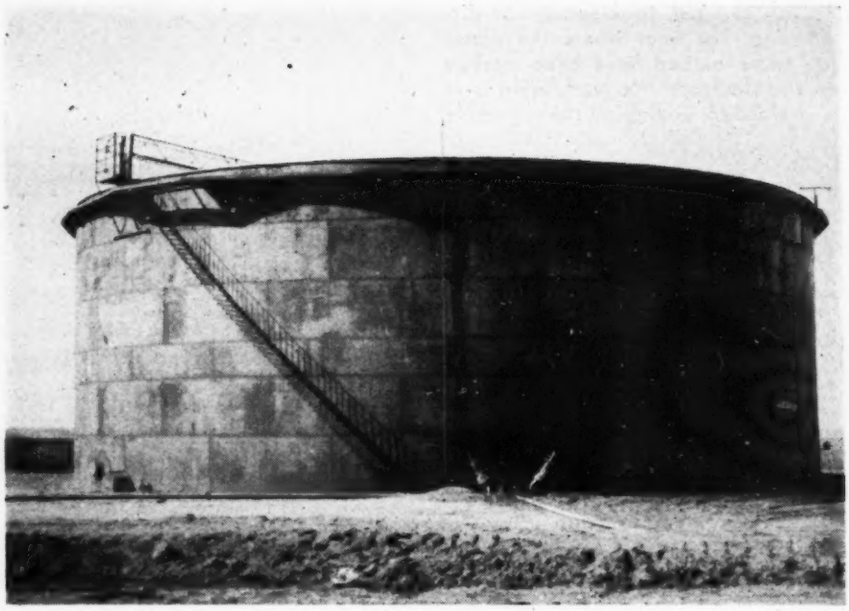
The project consisted of laying 383 miles of 16-in. diameter pipe by the most direct route from the Slaughter pool in Hockley County, Texas, to Drumright, Oklahoma; 10 miles of 8-in. pipe and 7 miles of 16-in. pipe to connect to existing lines in the Wasson area; the construction of pumping stations at Slaughter and Wasson; one intermediate pumping station; and storage tanks at Wasson, Slaughter, Drumright, and 12 locations along the existing Stanolind pipe lines in Kansas, Missouri, and Illinois.

As first planned, with pumping stations at Slaughter and Wasson only, the capacity of the new line would be 54,000 bbl. a day. One intermediate station was added between Slaughter and Drumright, increasing the capacity to 64,000 bbl. This can be stepped up to 116,000 bbl. by installing additional intermediate stations in the future.

The War Production Board approved construction of the new line provided the use of essential war materials would be controlled and second-hand steel plates used for approximately 95 per cent of the total tonnage required for the tanks. New carbon steel was allotted for the 390 miles of 16-in. pipe. The 10 miles of 8-in. pipe were supplied from reclaimed lines.

To build thirteen 85,000-bbl., four 30,000-bbl., and ten 20,000-bbl. tanks from used plates at 15 locations presented a problem of considerable proportion. The only existing tanks avail-

The first tank completed at Brownfield, Texas



able from which suitable material could be obtained were located at Casper, Wyoming. These tanks were of riveted construction with conical steel roofs, built in 1922 and 1923, and had been used for crude oil storage. Inspection indicated that the plates in the shells and roofs were in good condition and satisfactory for use in rebuilding tanks. The upper surface of the steel bottoms was in good condition and records showed that, in the Casper area, there was little deterioration on the underside of steel tank bottoms.

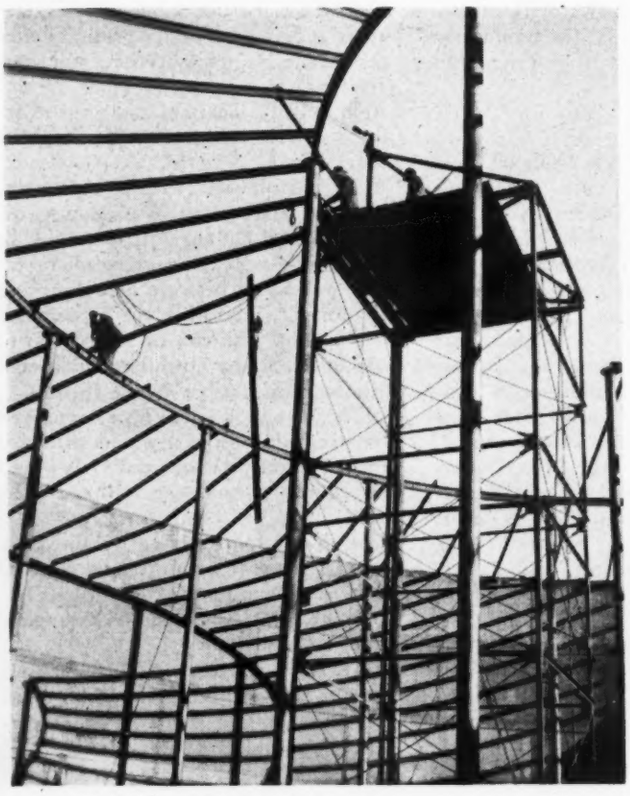
The Stanolind Pipe Line Company decided to use welded construction in rebuilding the tanks and equip them with Wiggins pontoon roofs. Pontoon roofs were chosen for two reasons: First, to reduce evaporation losses and maintain the gravity of the crude and, second, to eliminate the active vapor space above the liquid in the tanks in order to prevent corrosion on the underside of the roofs. West Texas crude is highly corrosive when vapors from the crude are allowed to combine with air in the active vapor space of a cone roof tank. Experience has shown that this corrosive characteristic is greatly reduced when the active vapor space is eliminated by using floating roofs.

Tanks Dismantled

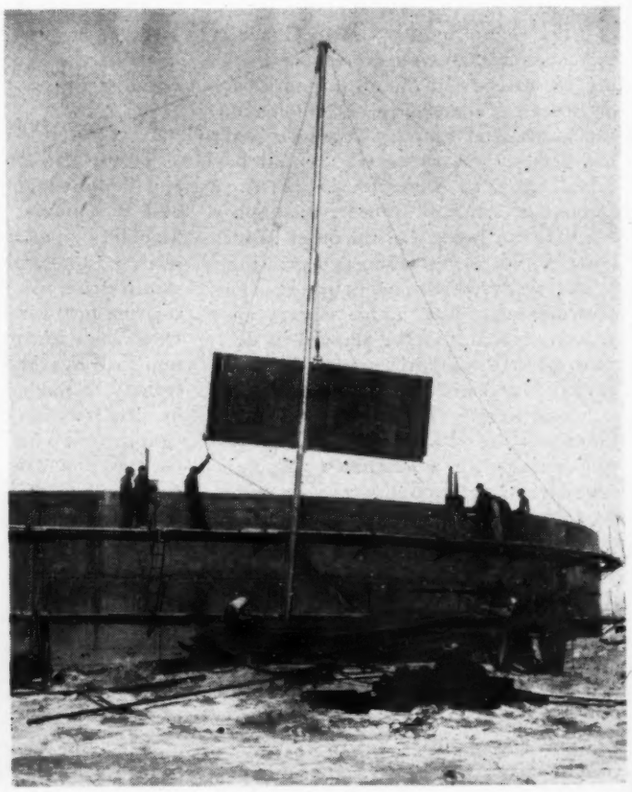
Thirty 80,000-bbl. tanks were dismantled at Casper to provide material for the re-erected tanks. All plates for the butt-welded shells and the welded bottoms came from the Casper tanks. The main plates for the decks and pontoons of the floating roofs were also fabricated from plates taken from the dismantled tanks. The only new material in the tank shells and bottoms is that in the nozzles and stairways and the only new material in the roofs is that required for the shoes, seals and fittings, and miscellaneous small bars and shapes.

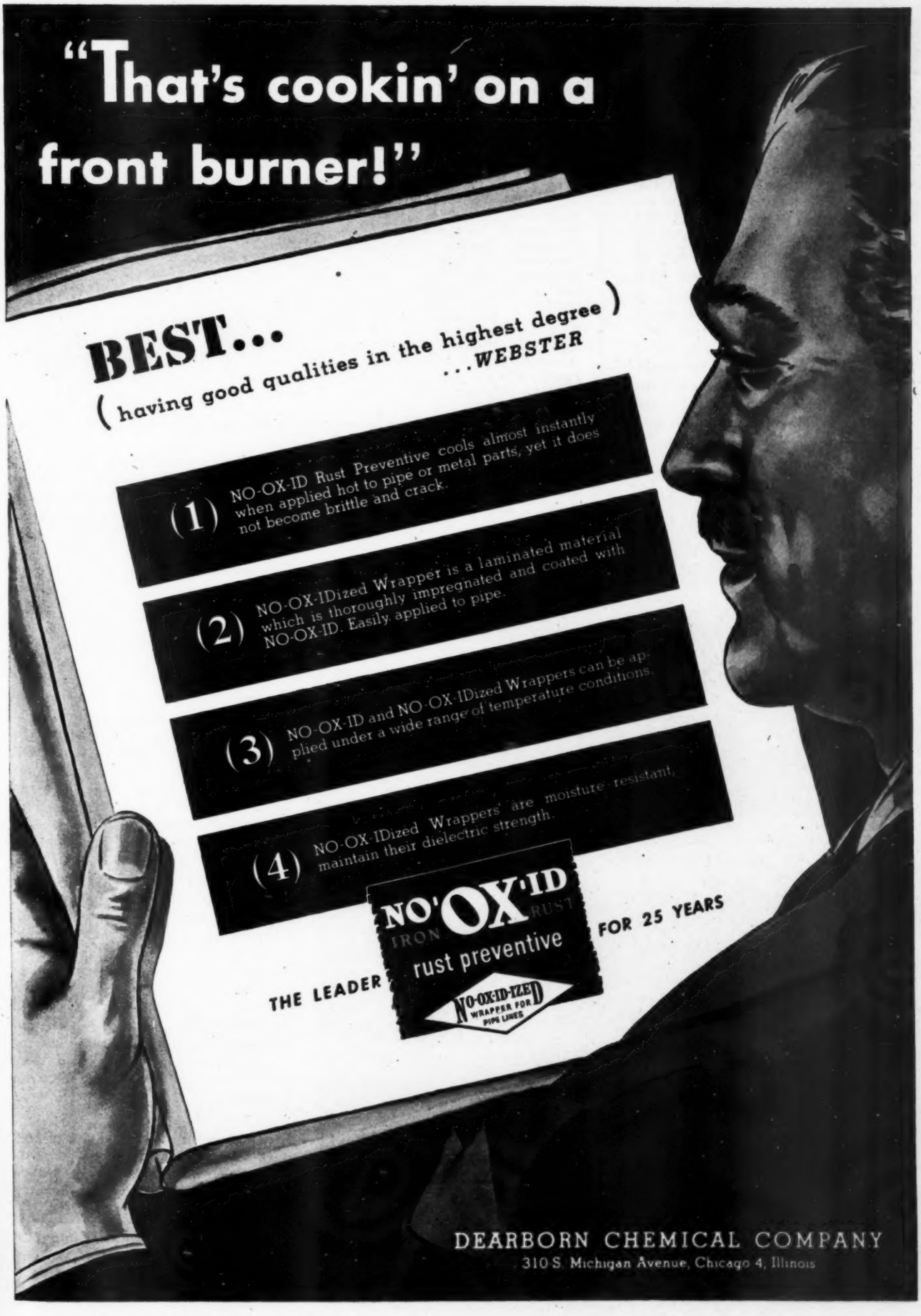
The tanks at Casper were dismantled by burning off the edges of the plates adjacent to the riveted joints without removing the rivets. A burning ma-

A structural buggy is being used to dismantle the roof framing on this 80,000-bbl. tank



Dismantling gang lowering a plate, which is to be burned, from third ring of the tank

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chine was devised to cut along both sides of the riveted seams in the roof plates simultaneously.

The old tanks were first cleaned and the wax removed from the inside of the tank shells. Before beginning to cut down the tank shells, all plates were carefully marked and scaffolding erected from which to operate the burning machine. A burning machine was also developed to cut above and below the horizontal seams at the same time. The ends of the plates were cut off by burning a single cut with a torch, first on one side of each riveted vertical joint and then on the other.

The dimensions of the tanks to be rebuilt were determined so that each plate, as it was dismantled, was cut to fit into the particular tank for which it was intended. When dismantling the old tanks, care was taken to burn the plates so that the edges would be suitable for re-erecting as butt-welded structures.

Re-erecting Tanks

The fitting up and the welding of the tanks as they were rebuilt presented problems not encountered in the erecting of butt-welded tanks from new steel plates. As could be expected, the plates were not cut so accurately as they would have been fabricated in a shop and considerable time and expense were required to assemble the plates, fit them up, and weld them. Because of the increased number of welded seams, due to the recovered plates being smaller than those ordinarily used in new tanks, care was necessary to make the tank shells true and round. With close supervision many of the re-erected tanks are as smooth in appearance as tanks built from new steel.

Location	Number of tanks	Capacity (each) bbl.
Brownfield, Texas (Slaughter area)	6	85,000
Seagraves, Texas (Wasson area)	4	40,000
Drumright, Oklahoma	3	85,000
Sycamore, Kansas	1	85,000
Centerville, Kansas	1	20,000
Freeman, Missouri	3	85,000
Odessa, Missouri	1	20,000
Carrollton, Missouri	1	20,000
Marceline, Missouri	1	20,000
Wyaconda, Missouri	1	20,000
East Fort Madison, Illinois	1	20,000
Ormonde, Illinois	1	20,000
Laura, Illinois	1	20,000
La Rose, Illinois	1	20,000
Ransom, Illinois	1	20,000

The locations of the re-erected tanks are shown in the table on this page.

There are four major river crossings between Slaughter and Drumright, Oklahoma, all of which are being laid in de-watered open trenches below the scour line. The trenches are dewatered by means of rows of sand points upstream and downstream from the crossings. This method of installing river crossings is not new, but only recently has become general practice where conditions permit its use.

Construction of the new line was begun in November, 1943, and is scheduled for completion in April, 1944. Dismantling of the old tanks at Casper began September 1, 1943, and the re-erected tanks at some locations are already in service. The remainder will be finished and the pumping stations will be completed by April, 1944. The old tanks were cut down at Casper and the re-erected tanks and floating roofs were installed by the Chicago Bridge & Iron Company.

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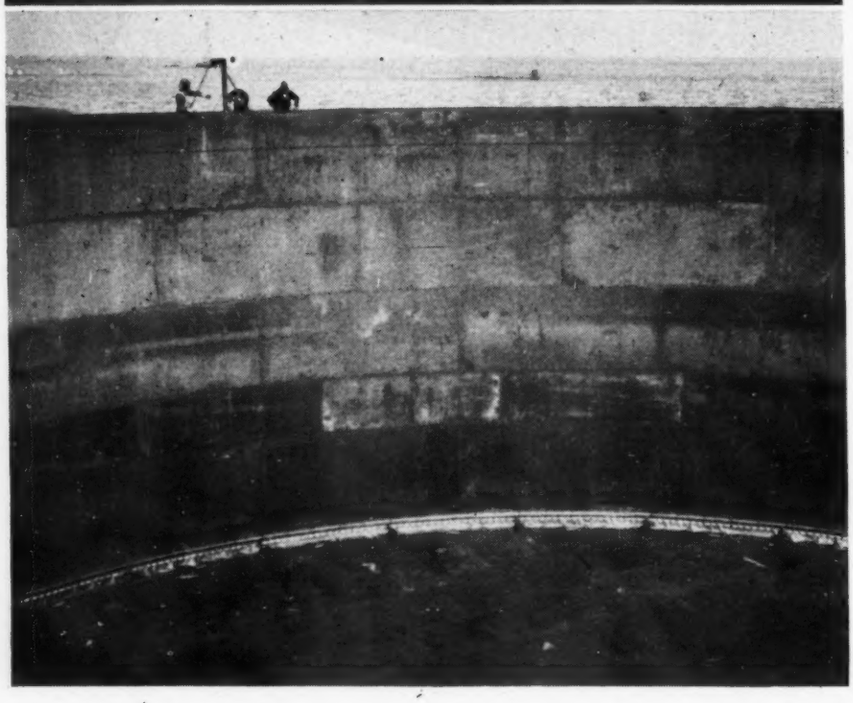
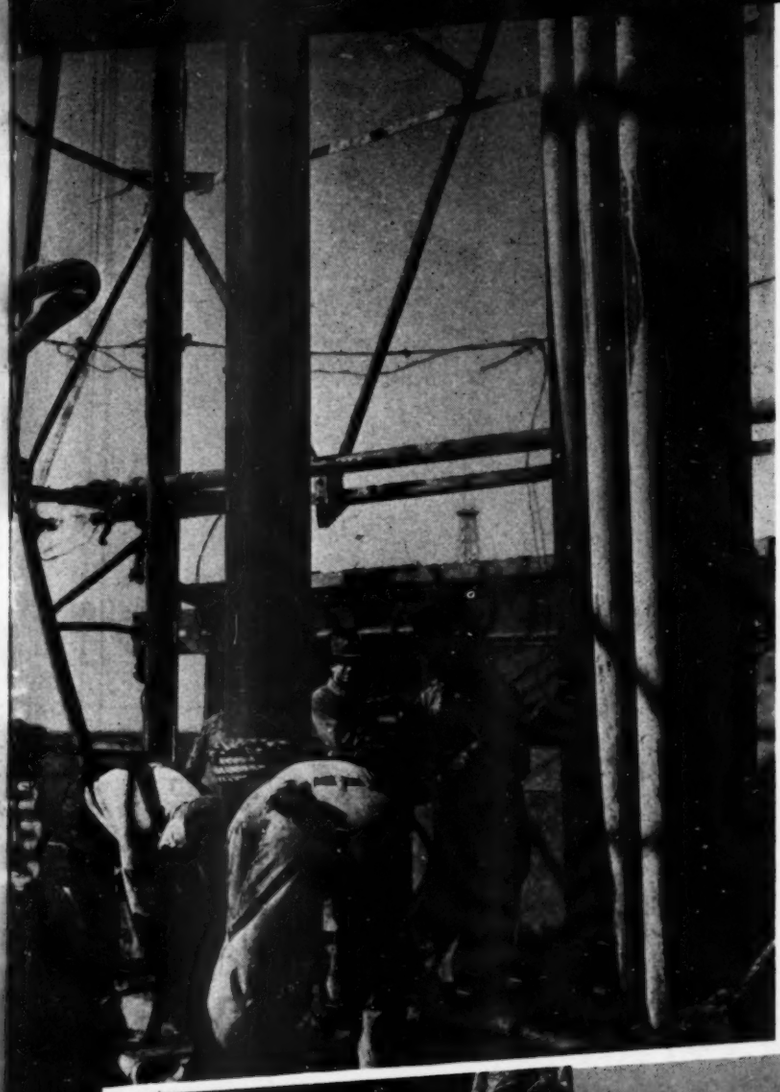


Top—Close-up showing center of high deck pontoon roof riding on crude oil in second tank completed at Brownfield. The center pontoon of the pontoon roof shows clearly

Bottom—Looking downward into a re-erected tank, showing the Wiggins pontoon roof resting on the roof supports before the tank is filled with oil

They're glad they used



THE war has made it necessary to get the utmost use out of oil field and refinery equipment. Drillers have been forced to conserve the limited strings available. Casing in old wells has been pulled and used over again. Even complete pipe lines have been dug up and laid down again in more important locations.

All this hard use and re-use of pipe and tubing has focused attention on how all-important is the matter of giving the utmost care and deliberation to "overall" or, "in the long run," economy in the selection of materials.

NATIONAL Seamless is piling up some amazing records. Old customers have told us again and again they are glad they used seamless because of the punishment it can take in these emergency conditions.

In heavy-worked refineries too, NATIONAL Seamless is backing up the judgment of those responsible for its selection. Production has been maintained at peak capacities with a minimum amount of time lost for "off-stream."

When conditions ease up and more pipe, casing, and tubing become available, remember why these long-time users are glad they used Seamless.

NATIONAL SEAMLESS Drill Pipe, Casing and Tubing are giving "yeoman's service" in America's great oil fields to furnish the unprecedented demands of War to keep the moving parts of mechanized equipment rolling and planes flying.

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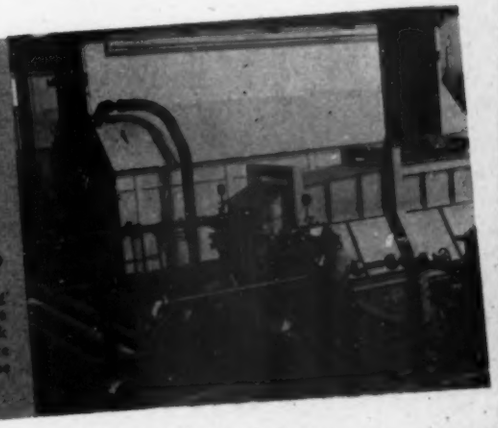

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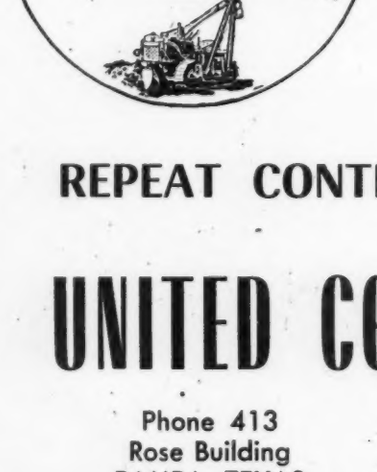

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Feature

☆ Multiplicity of products handled entails specific problems

by Fred J. Plattner

General Superintendent, General American Tank Storage Terminals

GENERAL American Tank Storage Terminals, a division of General American Transportation Corporation, operating a large public bulk liquid terminal system, has terminals at Corpus Christi and Galena Park (Port of Houston), Texas; Goodhope and Westwego (Port of New Orleans), Louisiana; Carteret (Port of New York), New Jersey, and Panama City and Jacksonville, Florida, the latter two being owned by Defense Plant Corporation.

Facilities afforded the customer have all the advantages of his own terminal without investment on his part, and although tremendous quantities of oils and other liquids are handled, at no time does the operating company buy, sell, or own any of the materials.

Varied Commodities

Not only is a complete range of petroleum products handled but also various coal tar fractions and a wide variety of vegetable oils, as well as whale oil, sperm oil, and many other liquids. At one terminal recently 44 different varieties of material were on hand at one time. Included were 12 different grades of petroleum naphtha, all water white and all looking alike and yet all different in boiling range and other specifications. From this it will be seen that the greatest care must be taken to prevent the possibility of contamination and facilities must be flexible enough to handle this wide variety of materials.

Refineries

At both of the company's Texas terminals customers have erected refining units and crude oil is brought in by pipe line. The refineries are equipped with relatively small run-down tanks and storage is used for the crude oil as well as all finished products, from aviation gasoline to bunker oil.

At another terminal a benzol fractionating unit has been erected and operates on a similar basis.

Contamination

The protection of specifications of customer commodities and the prevention of contamination is one of the first considerations in laying out a terminal. So far as is practicable all commodities are segregated into separate parts of the plant. In every case each tank has its own pipe line and frequently its own pump to prevent possibility of two commodities commingling. It is the company's practice never to tie two or more tanks into the same piping and pumping system unless they all carry the same grade of material.

Instead of manifolding tanks together in the usual way and depending on valves, a line is carried from each tank to a common location and terminates in a valve and blind flange. When it is necessary to move into or out of any given tank the blind flange is removed and a standard flanged elbow or a special spool piece permits tying into the proper piping system. When the movement is completed this fitting is removed and the blind flange replaced. In this way the tank and its own line are a completely separated unit, entirely divorced from everything else, and allowing no possibility of contamination either through human or mechanical failure.

Docks

The nature of the business requires that docking facilities be provided for deep draft vessels and at two of the company's terminals two ships can be docked simultaneously. More or less frequent dredging is necessary in some locations to maintain the proper depth. Docks generally are of pile and timber construction.

Two of the terminals are situated on the lower Mississippi River where there are seasonal changes in the stage of the river to the extent of approximately 30 ft. The barge handling dock is a floating barge tied on the shore side of large pile clusters with a hinged catwalk leading ashore so that the entire equipment can rise and fall with the river. Oil lines are carried ashore through swing joints to provide the necessary flexibility. For a long time trouble was experienced at the Goodhope terminal during high water because of the swift current and also because the terminal is situated on what the U. S. Engineers term a caving bank. During high stages of the river pressure is exerted on the bank, causing it to slide into the river and this pressure is so great that no pile and timber dock could withstand it. As a result the company frequently found its dock being washed away by floods. Several years ago a structural steel, all-welded dock was constructed

Aerial view of terminal

with vertical members made of 30-in. "H" beams 150 ft. long, driven to about 120 ft. below the low stage of the river. A structural steel runway carries back about 400 ft. to the top of the levee and on into the terminal. All pipe lines, as well as an inclined runway for drums, are carried on this structure. Since this structure has been built little or no trouble has been experienced and the theory is that the long H beams carry down far enough to terminate in stable footing.

Pumps

Because of the wide variation in viscosity of materials handled it is necessary to use several types of pumps. The lighter materials are usually handled with electric motor driven centrifugal pumps and the more viscous oils with steam reciprocating or electric motor driven rotary pumps.

Steam Facilities

Large steam capacity is required due to heavy demand for steam to heat large tanks on short notice. Steam also plays an important part in the cleaning of storage tanks. A considerable part of the pumping is done with steam power so that high pressure steam is important and uninterrupted pressure must be maintained. Boiler capacity ranges from 200 to 2000 hp. at each terminal. At several locations natural gas is used and at others bunker C oil is used as fuel. At Goodhope, Louisiana, the only source of boiler feedwater is from the Mississippi River, which makes it necessary to maintain an elaborate settling and filtering plant to condition the water. In its natural state it carries such a heavy content of silt that it is virtually opaque. A rather extensive system of steam mains must be carried from the boiler house, radiating to various tanks and pumps. As a rule the company's terminals cover 40 acres or more so that distances are rather great.

Covered Pipe Lines

In the case of heavy lubricating stocks, vegetable oils, and bunker oils, especially at the Carteret, New Jersey, terminal, it is found necessary to cover pipe lines and carry a steam line wrapped together with the oil line. In some cases a tube type heater is placed in the line. These provisions are for the purpose of keeping the oil liquid and free flowing. In the case of bunker oil, large quantities are delivered into customers' trucks and this requires temperatures averaging about 125°F.

Tank Sizes

A wide range of tank sizes is required, ranging from 5000 to 96,000 bbl. Pipe line sizes ranging from 4 to 16 in. and pumping capacities are as high as 8000 bbl. per hr.

Vents

All tanks are equipped with flame arresters and snuffers, as well as pressure and vacuum vent units, giving protection to materials and reducing the evaporation losses to a minimum. Practice has been to paint tanks either with aluminum or white paint with a view to conserving commodities.

Tank Coils

It is also necessary that most of the tanks be equipped with steam coils for heating heavy materials. Use is made of tank heating facilities to blend or compound lubricating oils in large batches.

Tank Stripping

Because of the variety and frequent change of commodities it is necessary to empty tanks completely in order to deliver all of a certain customer's material and to clear the tank for another use. Because of this tanks are equipped with sumps and special stripping connections that allowed such an operation with a minimum of labor.

Tank Cleaning

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OKLAHOMA CONTRACTING COMPANY

tion is the necessity for frequently changing tanks and pipe lines from one service to another. These changes are limited as much as possible and in some cases a shift can be made from a dark colored oil to water white material by working through a third tank that may have carried an intermediate grade. This is not always possible, however, as all tanks are usually occupied.

The practice is to pump out all the heavy oil possible, then go into the tank with a large crew of men and squeegee the bottom until all liquid has been removed. The next step is to turn live steam into the tank and get it hot enough so that any oil remaining on the sides and roof support columns will thin out and run down onto the floor. After the tank is allowed to cool and is aired out, another crew enters and washes down the sides with a fire hose discharging water under high pressure. If the new commodity is to be water white material the bottom is dried with sawdust and another steaming given, this time with a quantity of trisodium phosphate or caustic soda introduced with the steam. Additional cleaning by hand scrubbing may be necessary, especially around the bases of roof support columns. When it is realized that a large storage tank contains from 20,000 to 30,000 sq. ft. of surface in the sides and bottom, it can readily be seen that this is a large undertaking. We have gone so far as to change tanks from cylinder and bright stock service to water white toluol having a boiling range of only 1°C. This will give an idea of the thoroughness with which such cleaning must be done in order to guard against contamination.

Packaging

During the last several years packaging facilities have been greatly increased. Many hundreds of thousands of containers have been filled with commodities ranging from aviation gasoline to heavy grades of lubricating oils and even paraffin wax. These containers range in capacity from 5 to 55 gal. each. At one plant as many as 8500 55-gal. drums have been filled per working day of 24 hr. and loaded into cargo ships. Straight cargoes containing as many as 56,000 drums have been loaded and we have had on hand as many as 50,000 filled drums awaiting the arrival of a ship.

In the case of smaller containers women are employed with excellent results. These containers can be filled at the rate of 10,000 per day. As a general rule the smaller containers are loaded into box cars or onto lighters in quantities of 10,000 to 12,000 cans per lighter. Containers are handled on roller conveyors and filled by weight, the gallonage being computed by the specific gravity of the oil so that there is no question about the net amount delivered into each package and no consideration need be given to variations in temperature.

Tank Cars

The war emergency has changed operations considerably and many thousands of tank cars and tank trucks are now being loaded and unloaded. This has made it necessary to install more racks and additional railroad sidings.

Inventory Records

Each customer is provided with a record of all inbound and outbound movement and as a double check a ledger record is kept on each tank, both at the terminal and at the general office of the company in Chicago. In this way there is a day to day control of the inventory balance and it is known at all times just how the inventory stands from an over and short standpoint.

The daily gauge report carries the date that each tank was last gauged, and in the case of dormant tanks, it is a rule that every tank must be physically gauged every seven days; of course, any time a tank has a movement in or out a physical gauge is taken.

All tanks have been calibrated down to 1/16 in. of depth by authorized agencies and these tables are recognized by the trade as being official and are used to develop receipts, shipments, and inventory balances.

Warehouse Receipts

An interesting and different angle of the company's operations is that warehouse receipts are issued either in negotiable or non-negotiable form, which are recognized by all banks as collateral. The negotiable type receipt is used as evidence of ownership in the transfer of material from one owner to another. The non-negotiable type is usually used as proof that the quantity of material covered is on hand in the company's possession and these are used as collateral security against bank loans.

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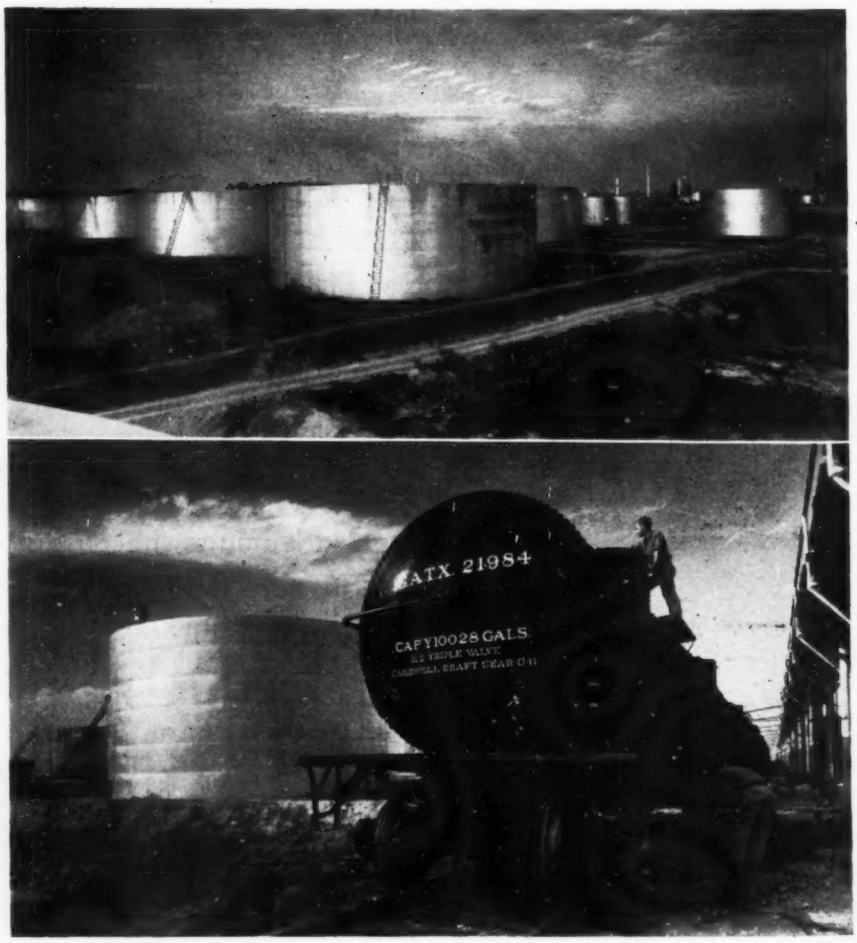

Top—Group of water top tanks
Bottom—Car at terminal loading rack with one workman hooking up hose to pump out contents and the other ready to inspect the car

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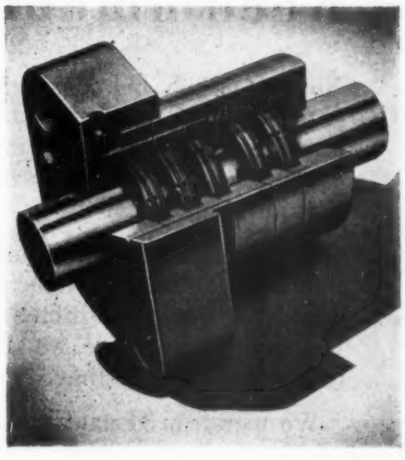

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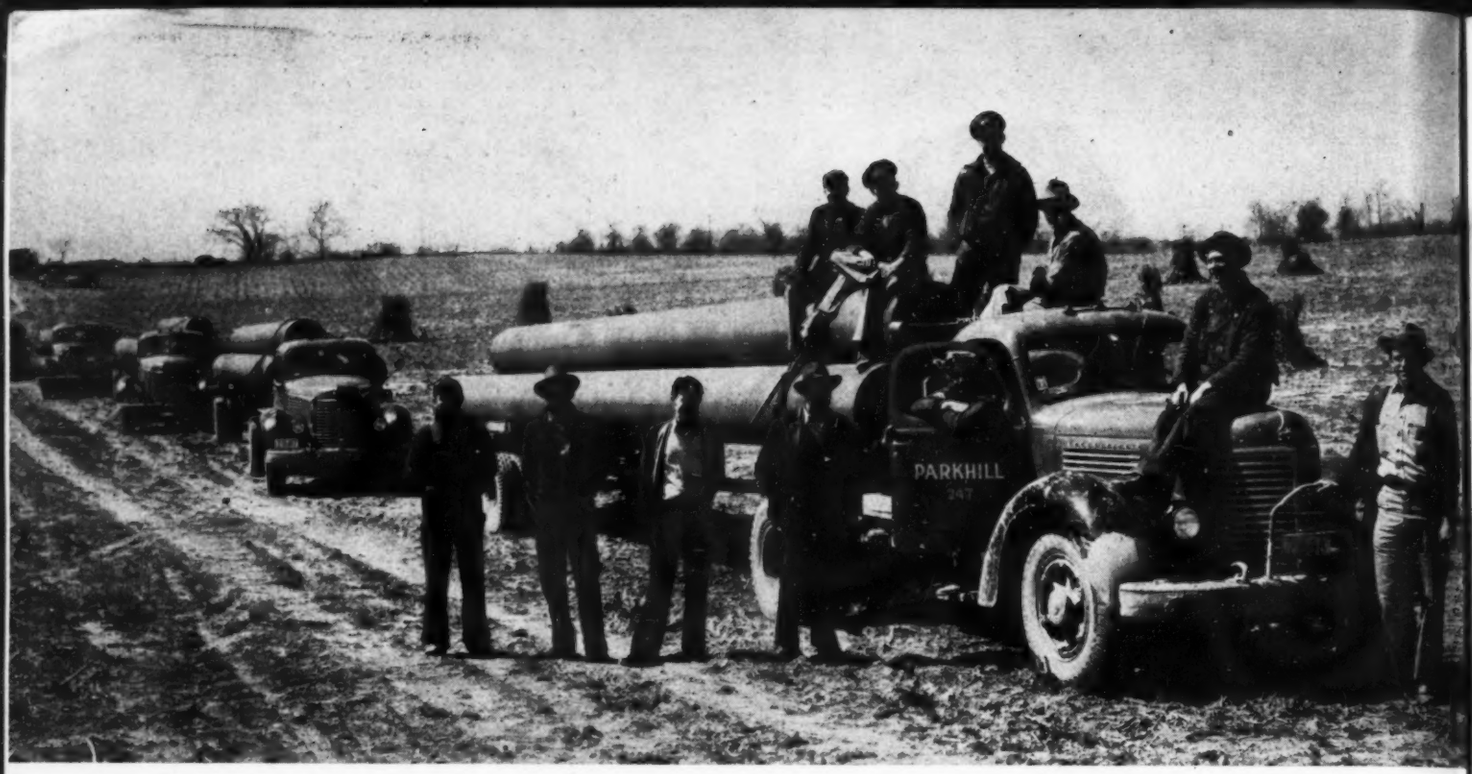

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P 615.223.

Mechanical Couplings For Pipe Lines

☆ Types of couplings, their application, and installation methods

by George E. Szekely

Engineer, Dresser Manufacturing Company

THE last decade has seen a more diverse use of mechanical couplings in the oil industry. This usage has extended to production, gathering, refining, transmission; in fact, wherever pipe is required. The trend has been accelerated by the war-stimulated demand for quick expansion of production and distribution facilities, together with the need of the armed services for portable, quickly-constructed supply pipe lines to bases and battlefronts.

The mechanical coupling is distinguished from other pipe joints principally by its use of resilient gaskets forming a seal directly on the pipe surfaces at the joint, construction being such as to afford substantial joint flexibility. The flexible mechanical coupling permits longitudinal and angular pipe movement, thus avoiding stresses in the line from temperature changes, ground or structure settlement and shift, equipment vibration, shocks, and other factors.

Construction

A mechanical coupling having widespread applicability to the various phases of oil field service is the bolted positive-seal type. This type may be used advantageously on lines operating under vacuum, or at highest pressures normally utilized, under almost all service conditions. The coupling is suitable for use with steel, cast-iron, or other kinds of pipe of all sizes. Pipe is plain end, no special preparation being required.

Component parts of the coupling are the middle ring, two wedge-shaped resilient gaskets, two follower rings, and a series of bolts, the number of bolts varying approximately in proportion to the size of pipe. The function of the middle ring is to sleeve the joint and provide spaced packing recesses for the gaskets, the distance between gaskets being sufficient to permit angular and longitudinal movements of the pipe without withdrawal from the coupling. In sizes 3 in. I.D. and larger, the middle ring is provided with a pipe stop or center bead to facilitate centering the ring over the joint.

The gaskets seat in the conical flares at the ends of the middle ring. The wedge shape affords ease of assembly without accurate alignment, high sealing efficiency with minimum volume of gasket, and maximum overall flexibility of the assembled joint. The gasket material in general use is a specially prepared rubber compound designed to provide the optimum combination of requisite resistance to set, cold flow, and deterioration with best packing qualities and flexibility. Asbestos gaskets are used for high temperature applications.

The follower rings cooperate with the middle ring to confine the gaskets and maintain the sealing pressure applied by drawing up the bolts. Parts are proportioned to insure gasket pressures that will seal the joint against line pressures as high as 1500 lb. per sq. in. or more with adequate safety factor. The seal is independent of line pressure and unaffected by factors tending to disturb the joint, such as shock, vibration, temperature changes, settlement, etc. Stresses induced by these external influences are safely absorbed by the resilience of the gaskets.

Gasket Life

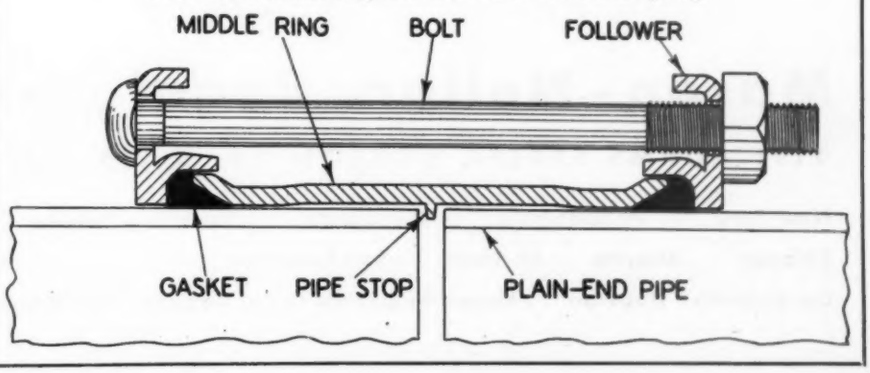
Indefinite maintenance of the gasket seal is insured by close confinement, which obviates appreciable loss of gasket pressure due to cold flow. Confinement also positively protects the gaskets against the deleterious effects of air, light, and heat. These and other potentially deteriorating influences are further minimized by the gaskets being entirely under compression. Experience with mechanically coupled pipe in continuous service for periods up to 40 years or more indicates that under most conditions coupling gaskets have life expectancy at least equal to any of the other components of the pipe line or piping system.

During the earlier history of the mechanical coupling, its use in oil field service was somewhat deterred by doubts regarding the performance or life of gaskets in contact with oils, gasoline, and other petroleum derivatives, most of which affect the properties of rubber compounds. Much of the doubt arose from unsatisfactory experiences with rubber compound articles under conditions totally different from those prevailing in the couplings. Where rubber parts had been freely immersed in oil products, or exposed to attack under tensions, swelling, sloughing, and consequent early failure were the common results.

Present day coupling gasket design

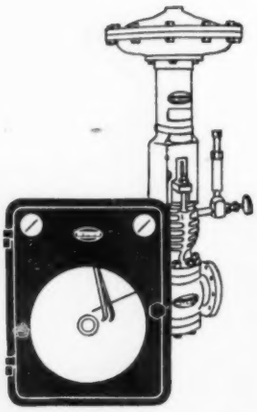
(Continued on Page 178)

Cross-section showing construction of bolted coupling



MASONEILAN

Keep Petroleum Products



Masoneilan Controls . . . are in practically every major pipe line where controls are used . . . are helping to keep petroleum products flowing for victory. The wide selection of Masoneilan equipment for over 110 stations* is ample proof that Masoneilan Controls meet all pipe line operating requirements.

Sturdy, dependable, and accurate, Masoneilan control equipment is also meeting the requirements of other phases of the petroleum industry.

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CONTROLS
Flowing For Victory

***MASONEILAN CONTROL-EQUIPPED STATIONS**

PIPE LINES	NO. OF STATIONS
War Emergency Pipe Line (Little Big Inch)	29
Sinclair Refining Company	13
Plantation Pipe Line Co.	27
Shell Pipe Lines	22
Bayou Pipe Line System	8
Portland Pipe Line Co.	7
White Eagle Pipe Line	4
Magnolia Pipe Line Co.	4

Coupling installed on terminal lines

(Continued from Page 175)

has overcome the former objections to use of gasketed joints in petroleum products service. First, great strides have been made in the art of rubber compounding in the direction of increased oil resistance. The resistance to attack in the case of the mechanical coupling gasket is appreciably enhanced by the maintenance of the gasket under high compression, whereby the material is rendered more impervious than in the free state or under tension. Second, the modern gasket is provided with a permanent, positive protection against the effects of the line contents.

The Armored Gasket

The earliest types of gasket protection were in the form of lead or duck sheathing, which, although satisfactory in protective qualities, to some extent reduced the effective packing surface, mechanical strength, and flexibility of the gasket. The armored gasket, developed and extensively utilized on oil service within the last decade, is a fully protected gasket having all the desirable qualities of a plain gasket. The armor is a close-coiled, endless helix of brass wire embedded in the tip of the gasket. Seating against the middle ring flare and pipe surface, it closes the clearance space between middle ring and pipe, thus preventing attack of the gasket by the line contents. Such small seepage of fluid as may pass through the minute interstices of the armor coils cannot affect the gasket, as the armor prevents flow of the gasket material, thereby arresting access of the fluid to the body of the gasket.

The armor coils are so strong transversely that they cannot be crushed by gasket pressure or other mechanical loads imposed on the armor in service. Circumferentially, the spring-like armor construction affords flexibility fully equal to the body of the gasket, so that there is no detraction from the ability of the gasket to perform its function of maintaining a flexible, tight seal.

In addition to its protective function, the armor makes an excellent electrical bond, of particular importance when lines are to be cathodically protected or electrically drained for protection against corrosion. Being made of brass, the armor itself is virtually non-corrodible, except in the presence of strongly acidic fluids.

Installation Procedure

Simplicity of installation is another important feature of mechanical couplings. Normal procedure consists of slipping one follower and gasket and the middle ring over the end of the laid pipe, the other follower and gasket over the end of the laying length, stabbing the latter into the middle ring, inserting bolts, and tightening. The entire process from initial positioning to final tightening requires, on an average, only two man-minutes per bolt. An 8-in. coupling having 6 bolts can be installed in 6 min. with two men wrenching on opposite sides.

Variety of Applications

Although mechanical couplings are useful for virtually all sizes and types of pipe connections, further specific applications of interest to the petroleum industry are on gathering lines, tank connections, valves, terminal lines, salt water disposal lines, pumps, engines, and compressors. The ability of mechanical couplings to accommodate misalignment and absorb vibration, settlement, expansion, and contraction is of particular value in such installations.

In addition to its utility on new work the mechanical coupling is used for repairs, replacements, and insertions. For this type of operation the pipe stop or center bead is usually removed from the middle ring, permitting the ring to slide along the pipe. The replacement of a defective length of pipe with a new

Assemblying a coupling

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Repairs, replacements, and insertions are made with couplings used in pairs

length and two couplings is shown in an accompanying illustration. The new pipe does not have to be cut exactly to length, and if the laid pipe is sprung out of line, the flexibility of the couplings permits reconnection without realignment or relaying. Similar procedure is used for insertion of valves, pumps, or other accessories into existing lines. Equipment thus installed may be readily removed for repair or servicing.

Adaptations of Basic Design

The foregoing discussion has been largely directed to the general usage of mechanical couplings of the positive-seal type. There are many adaptations of the basic design previously described especially suited to specific conditions. Long couplings or sleeves are used to span gaps, as at random closures, where regular couplings may not provide sufficient distance between gaskets. Long couplings are likewise desirable when excessive settlement or other concentrated extensive movement may be expected.

The long coupling is not to be confused with the conventional expansion joint, the latter being intended for absorbing the longitudinal movement of long runs of pipe subjected to frequent temperature changes over a wide range of variation. As a general rule, mechanical couplings of the type here under consideration are capable of absorbing indefinitely longitudinal movements up to 3/8 in. per joint, which is approximately the amount of expansion and contraction in a double-random length of pipe subjected to normal atmosphere temperature variation. Occasional movement in excess of 3/8 in. per joint is not harmful, however, and long couplings may be used advantageously for excessive movements due to unusual seasonal temperature changes or occasional shut downs.

Insulating couplings are useful for breaking up stray electric currents. The gaskets in these couplings are provided with aprons that keep the pipes wholly free of electrical contact with each other. The insulating coupling is frequently used at wells, tanks, branch lines, and other locations to eliminate the collection or passage of current, an effective and inexpensive means of preventing or mitigating electrolytic corrosion in systems of pipe and structures.

Reducing couplings are convenient for connections between different pipe sizes, or to connect cast-iron to steel pipe. An almost unlimited variety of fittings, such as ells, tees, crosses, caps, adapters to flanged, screwed or other outlets, are available and they greatly simplify connections in complex piping, as around tank farms, pump stations, and refineries.

Boltless Fittings

Boltless couplings and fittings in sizes 2 in. and smaller are similar to the bolted types, except that threaded nuts screwing on a threaded middle ring compress the gaskets. Boltless couplings and fittings are particularly suitable to small piping in close quarters, around engines, compressors, pumps, refinery equipment, etc. They are shipped and installed completely assembled.

Re-Use of Couplings

Salvage value, an important attribute in peace-time, assumes increased significance in time of war, with its demand for conservation of time, materials, and labor. Mechanically coupled pipe lines that are no longer required for their original purpose can readily be picked up and relaid with a minimum of manpower and new materials. Ordinarily, minor repairs to pipe and cleaning, plus new gaskets and bolts for the couplings, are all that are required to recover the entire original line. Pipe ends have actually been protected while in service and need not be trimmed or cut off.

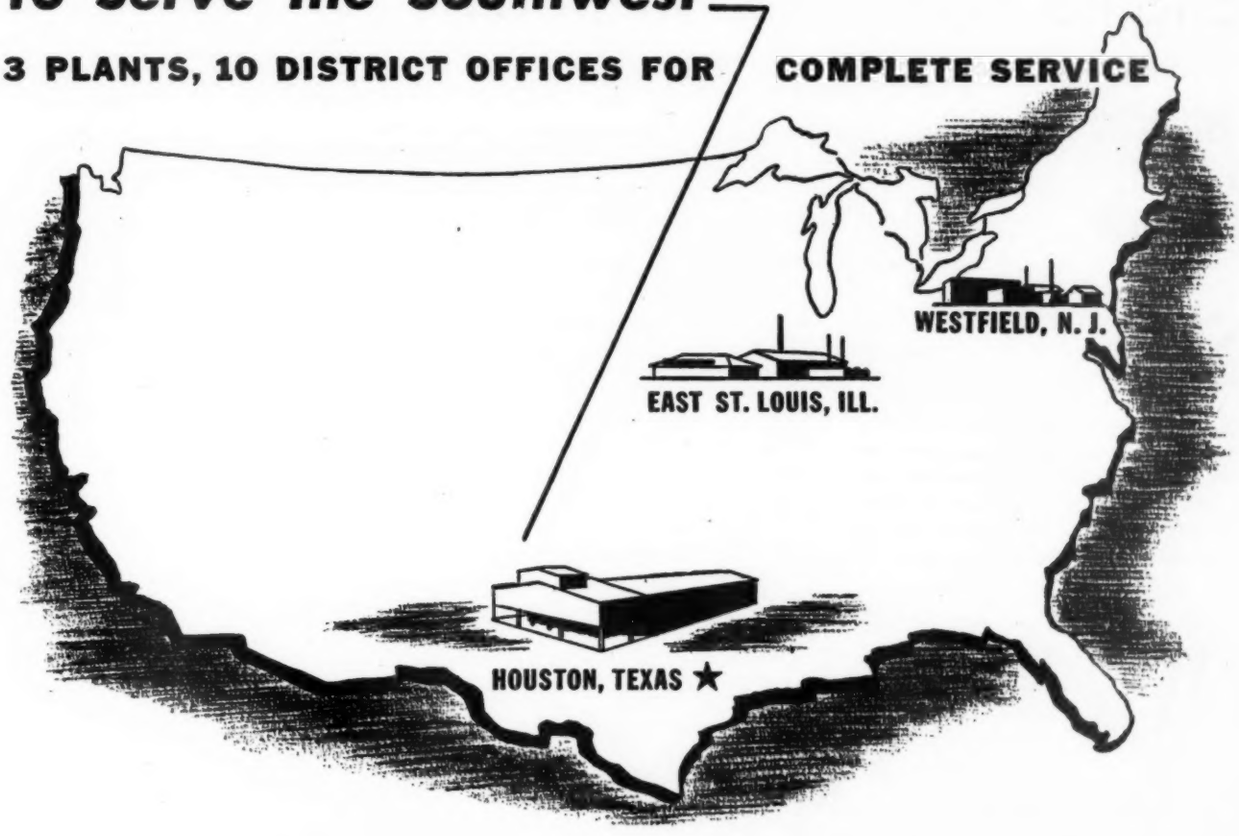
Due to the mobile character of modern warfare, portability is an essential characteristic of equipment for the armed forces, and the use of mechanical couplings for gasoline, oil, and water supply lines to camps, air bases, and the fighting fronts has been resorted to extensively. ——☆☆☆

Long couplings used on tank connections in gathering system

NEW BITUMASTIC PLANT

To Serve the Southwest

3 PLANTS, 10 DISTRICT OFFICES FOR COMPLETE SERVICE



TO complete the cross-country chain of Wailes Dove-Hermiston manufacturing facilities, a new plant is being constructed in Houston, Texas.

This plant will supply the needs of the Southwest for Bitumastic pipe coatings, supplementing the production work of the Westfield, New Jersey plant in the East, and the East St. Louis, Illinois plant in the Middle West.

Large stocks of the various grades of hot applied Bitumastic Enamels as well as full stocks of all cold applied Bitumastic Industrial Coatings will be available from the Houston plant. The use of Bitumastic coatings has grown to such an extent that today they have applications in every field where lasting and effective corrosion protection is required for plants, structures and equipment.

The Houston plant, located at 7002 Clinton Drive, is well situated to assure prompt freight delivery of Bitumastic coatings to all parts of the Southwest. For railway shipments the plant is served by a siding of the Houston Belt Terminal Railway. Speedy truck deliveries are also assured since the plant is located near the Beaumont highway, connecting with other major highways.

The plant is of fireproof construction and contains up-to-date manufacturing equipment and a control laboratory to maintain the high Bitumastic standard of quality. All materials requiring protection against weather will be stored under cover.

The first shipment to be made from the Houston plant will be an order of Bitumastic Priming Solution and Bitumastic XXH Enamel for the protection of the Tennessee Gas and Transmission Company pipe line now under construction between Corpus Christi, Texas and Kenova, West Virginia.

HOT COATINGS: Bitumastic Regular Enamel, Bitumastic XXH Enamel, Bitumastic 70-B Enamel, Bitumastic Priming Solution and 70-B Priming Solution
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P 625.4

Cold Straightening Compressor Engine Power Piston Rods

☆ **Economy of time and money effected by equipment designed by gas company engineers**

by W. E. Nestor

Superintendent of Compressor Stations, Arkansas Louisiana Gas Company

STRAIGHTENING power piston rods on large single and twin tandem double-acting gas compressor engines heretofore has been a difficult machine shop operation.

These rods are hollow to allow for circulation of cooling water to cool the piston and rod and spring out of alignment very easily when they become overheated and are cooled too quickly by operators turning cold water through them.

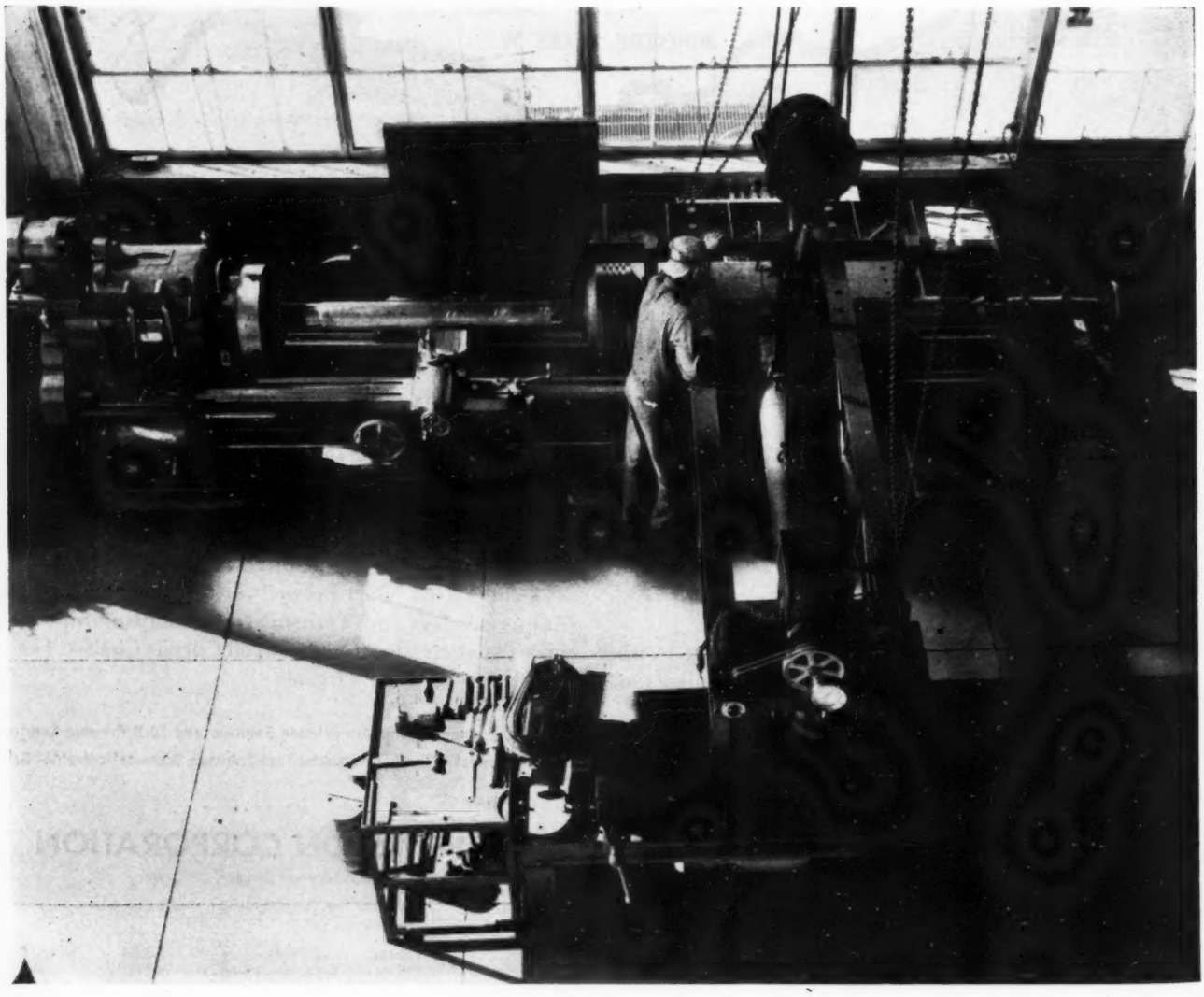
When the rod is sprung or bent excessively, it will result in increased wear to piston rod, metallic packing, cylinder walls, and piston rings, unless the rod is removed from the cylinder and straightened.

It has been general practice previously to place the rod in a large lathe, heat the bent area of the rod with an acetylene torch, and attempt to straighten the rod by pulling with a turnbuckle or screw jacks, or by means of leverage using a long crow bar resting on the cross compound of the lathe.

Either method places a tremendous strain on an expensive high grade lathe

Photographs by J. E. Hampson, Arkansas Natural Gas Corp.

View showing hydraulic press in place straightening a piston rod



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A-5	1/2	9/32	120	10
A-7	1/4	3/16	120	10
A-8	1/8	1/4	120	10
A-9	6-	5/16	300	5
A-11	1-1/16	1/4	120	50
A-12	1-	1/8	120	10
A-13	3/8	5/16	350	10
A-14	3/8	5/16	500	10
AB-1	15/16	3/8	350	5
AB-5	1/2	3/16	75	10
C-1	1-1/16	9/32	500	10
C-5	1/2	5/16	350	10
C-7	1/4	3/16	500	10
C-10	3/8	5/16	1000	10
CB-1	15/16	3/8	1000	5
CB-5	1/2	3/16	200	5
CB-7	1/4	3/16	500	5
CB-8	1/8	1/4	200	5
R-1	13/16	Rosette	120 each leg of three	5
R-2	1-1/16	Rosette	500 each leg of three	5
R-3	13/16	Rosette	120 each leg of four	5
R-4	1-3/16	Rosette	120 each leg of three	5

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SR-4 Strain Gages revolutionize field determination of static and dynamic stresses in structures and machines. Some types are as small as your little fingernail. Install any place you can reach, on plane or moderately curved surfaces, measure static strains to 1 part in 2,000,000 statically—nearly as small dynamically. No loss in linearity from 0 to 30,000 cycles/sec.

The Baldwin Locomotive Works, Baldwin Southwark Division, Philadelphia, Pa., U. S. A. Pacific Coast Representative, The Pelton Water Wheel Co., San Francisco, Calif. In Canada: Peacock Brothers, Limited, Montreal.

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Type A-1—one of 24. Ideal for all static strain measurements and recording problems. Ask for Bulletin 175.

SR-4 TORQUEMETER. *For determining torque in rotating shafts. Accurate, compact. Ask for Bulletin 165.*

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Sturdy, portable, self-contained. For production testing or laboratory work. Ask for Bulletin 169.

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Continuously records strains. Ask for Bulletin 170. (Also available: Scanning Recorder, serially records strain from 48 stations. Ask for Bulletin 172.)

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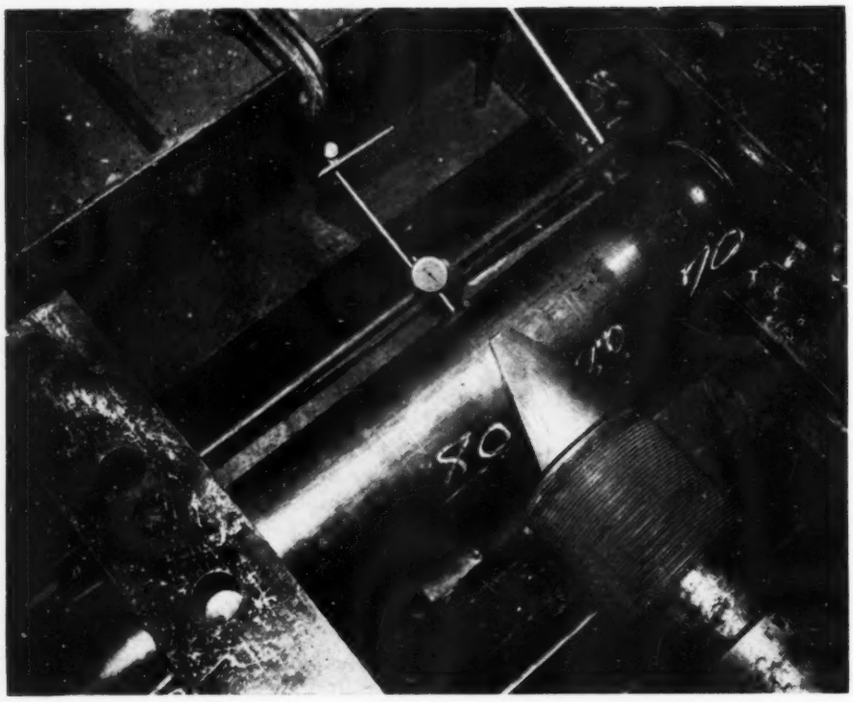


Close-up view showing dial indicator and nose piece on end of ram

at small cost and is driven by a ½-hp. electric motor through chain and sprocket connection.

The cylinder of this unit was bushed down from 2¾ in. to 2⅝ in. and a steel plunger with leather cup seal installed. The only other changes necessary was to supply an oil reservoir and attach the drive sprocket to the shaft.

The entire power unit is mounted on top of the press framework with gauge and controls accessible to the operator. Extra heavy pipe and fittings connect the power pump to an 8½-in. forged-steel cylinder into which is assembled a close fitting cast-iron ram with a leather cup seal in the cylinder. A special nose piece, shaped to fit the rod and copper lined to prevent scoring the polished surface of the rod, was fitted to the other end.

When a piston rod is kinked, it is removed from the engine cylinder and and may affect its accuracy for future use. At best, this is only a guesswork operation as there is no accurate means of determining the correct amount of force to exert on the turnbuckle, jack, or bar to bring the rod back to alignment. Also, when the rod has cooled off after this operation, in all probability it will have sprung back to the starting point and the operation must be repeated.

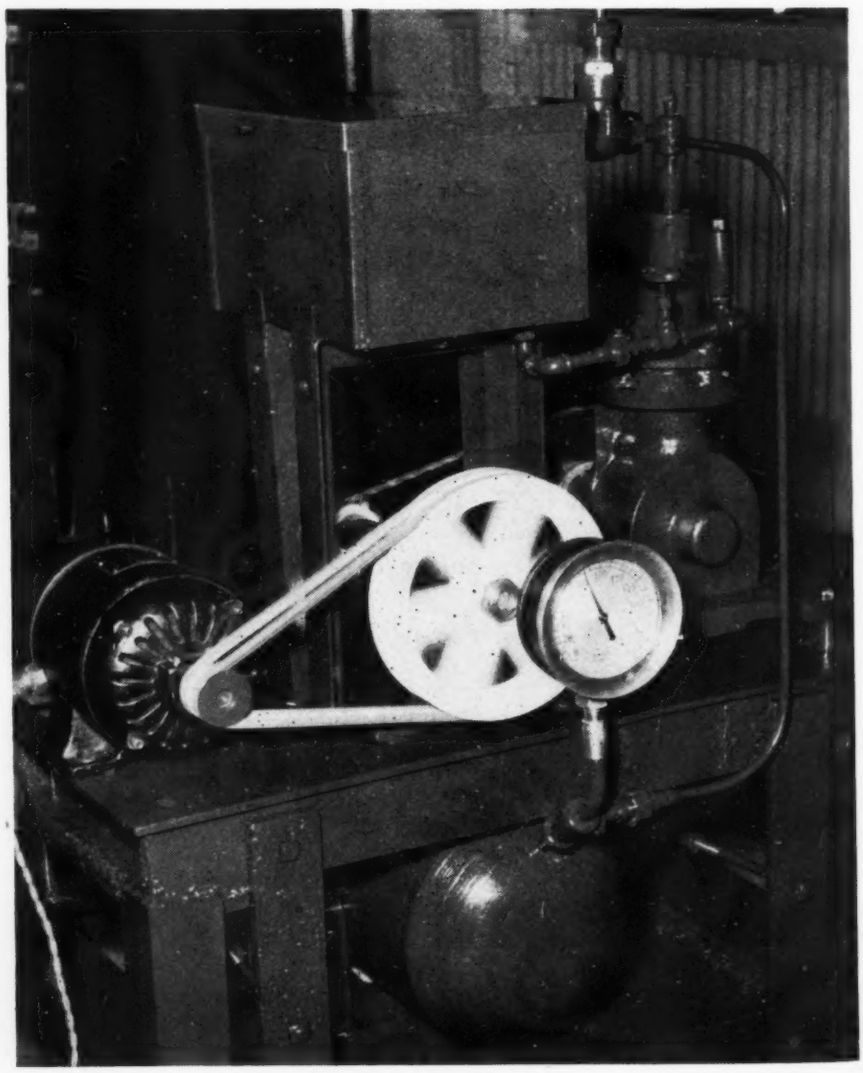
If the rod is allowed to cool gradually the heated area will become annealed. Inversely, if cold water is used the heated area will be more hardened than the surrounding surface.

In either case uneven rod wear results when the rod is put back in service and then it is doubtful whether the rod will be within 0.005 to 0.008 of alignment with its axis.

Seeking a speedier method of straightening rods, at the same time preserving the original Brinell hardness of the metal, compressor department engineers of the Arkansas Louisiana Gas Company designed a 200-ton hydraulic press to serve the dual purpose of removing pistons from rods for renewal and repair and of straightening the piston rods without heating.

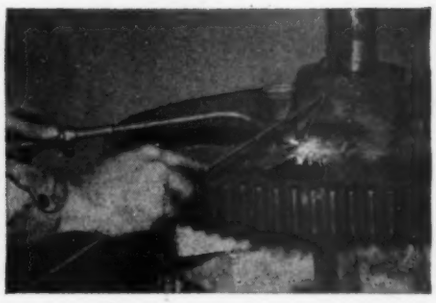
This press, a self-contained unit, was entirely fabricated in the company's main machine shop at Munce Compressor Station, Sterlington, Louisiana.

The pump supplying the power to the hydraulic ram was built from a small used refrigerating unit purchased



Power unit and end of hydraulic cylinder

These LINDE METHODS *Reduce Costs of* OIL FIELD OPERATIONS



OXY-ACETYLENE WELDING

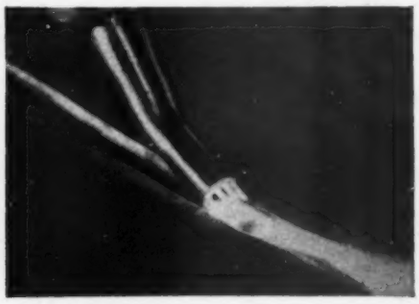
The oxy-acetylene flame makes possible the joining of practically any metals—like or unlike—so that the weld is as strong as the base metal itself. *Welded piping systems* in plants and refineries use less fittings, occupy less space, and remain leakproof indefinitely. Overland *pipe line welding* by Linde's steel-welding process produces strong, ductile welds in pipe of any size. *Bronze-welding* and resurfacing speed the repair of worn or broken parts and hard-facing with Stellite alloys makes parts subjected to abrasion, heat, or corrosion last from two to twenty-five times longer.

Straightening

Structural steel, shafts, pipe, plate, and other metal parts and structures that have become bent or warped can often be trued up in the shop or on the job by applying the intense heat of oxy-acetylene flames at the right points.

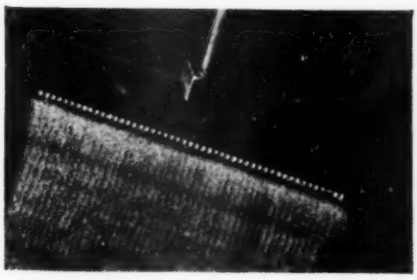
Hand-Cutting

Flame-cutting with manually operated blowpipes is useful for cutting pipe in the fabrication of piping systems. Hand-cutting also is used to cut structural steel in construction or alteration work—to reclaim old pipe—and to cut scrap to length.



Gouging

With Oxweld hand-cutting blowpipes equipped with gouging nozzles, surface metal—such as faulty or temporary welds—can be removed quickly leaving a groove, without need of grinding or chipping, and without harm to the adjacent areas.



Flame-Priming

This process removes loose scale, rust, and surface moisture from steel prior to painting —making paint go on faster, bond tighter, and last longer.

Heating

Heating for bending, straightening, and forming operations is facilitated by the oxy-acetylene flame. Shown here, a pipe is being wrinkle-bent.

Oxygen, Acetylene, Carbide

A booklet describing use of Linde oxygen, Prest-O-Lite acetylene, Union Carbide, and Oxweld apparatus in these and other processes will be sent without charge on request. Ask for P-13477.

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The words "Stellite," "Linde," "Prest-O-Lite," "Union," and "Oxweld" are trade-marks.

Here's all the "MACHINERY" You Need to Join Pipe . . . with Dresser Couplings

This wrench dramatizes the ease and speed with which any ordinary workman can join pipe with Dresser Couplings. It is the only tool needed to make flexible leak-proof joints — on plain-end pipe.

INSTALLATION TIME—about two man-minutes per bolt.

The skill necessary to make an efficient joint is factory built into Dresser Couplings — and it means more in these wartime days than ever before. No complicated expensive machinery, no exact pipe fitting. Installation can be made night or day, in any weather, in a minimum of working space.

"Dressers" are applicable wherever gas, oil and petroleum products, water and so forth are handled via pipe. They greatly simplify equipment and machinery settings. They protect your lines from damage by absorbing without leakage, expansion, contraction, deflection and vibration that would cause breaks in rigid connections.

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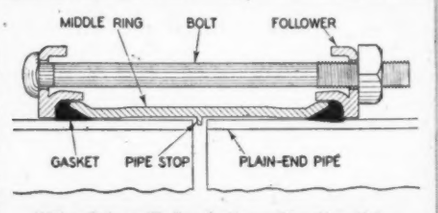

Working Principle—The flexible, bottle-tight seal is effected by resilient rubber-compound gaskets compressed between metal rings and against the pipe by bolts.

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taken to the machine shop where it is placed in the lathe and checked with a dial indicator to determine the point where the rod is bent and also to check the amount it is out of alignment. This point is then marked with chalk.

An overhead crane transfers the hydraulic press and places it over the rod at the point where it is bent. The rod is turned in the lathe until the high point of the bend marked with chalk is facing the ram. A distance piece with the copper faced nose piece attached is placed between the ram and the marked place on the rod.

A dial indicator is then set against the rod to check the work as it progresses. The pump is started and all the slack between ram and piston rod taken up and any movement of the dial noted.

The pump is again started and as the ram advances the dial is observed until the reading is from 0.030 to 0.040 greater than the amount of bend in the rod shown in the original check. This overpush is to allow for spring back when the ram pressure is released.

After the ram pressure is released the dial indicator is again set against the rod at the marked point and the rod is rotated in the lathe for a further check.

If it is found that the rod was not kinked back to accurate alignment, the operation is repeated and an additional allowance of 0.005 to 0.010 made for spring back. If, on the other hand, it has been found that the rod has been kinked back too far and bent in the opposite direction, the rod is given a half turn in the lathe and the operation repeated with less spring back allowance.

The amount of spring back allowance depends on the amount of bend in the rod found in the original check.

The writer has seen a bent piston rod from a 21½-in. by 36-in. twin tandem gas engine accurately straightened and placed back in the cylinder within 45 min. from the time it was removed.

Cold straightening not only eliminates heating, which affects the Brinell hardness of the rod and places a strain on the lathe, but speeds up the job to a point where in most cases the rod can be straightened in the time it would require to heat the rod for hot bending.

A tolerance of 0.001 plus or minus has been set up as good practice but more frequently the rods are straightened to accurate alignment.

As the majority of gas compressor stations are located in districts remote from large cities or towns where machine shops equipped to handle these large pistons are available, the job of repairing pistons and straightening rods becomes a very expensive item of maintenance, for in addition to the high labor costs, transportation to and from the machine shop must be considered.

Some gas companies return piston rods and other heavy parts to the factory for repairs, which results in freight charges to and from the factory in excess of the actual cost of repairs if done in their own shops.

A pressure of from 90 to 100 tons is required to straighten a badly kinked 7¼-in. power piston rod and pressures as high as 200 tons are sometimes required to break loose a piston from a badly corroded rod.

It is apparent, therefore, that gas companies having a large number of compressor stations to maintain can effect a considerable saving in transportation and labor costs by having a well equipped, centrally located machine shop to maintain in good condition the equipment of all their plants.

Additional economies can be effected by reduced inventories of heavy repair parts necessary for replacements while parts are being shipped to outside shops or the factory for repairs.

These facts hold true in peace times but are especially important in these war times when factories and machine repair shops are swamped with work and delays are inevitable. ——☆☆☆

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Leading Machinery Manufacturers are using Fel-Pro Packings as standard equipment; all industry is using them for replacement; because they're the best protection against power-weakening, money-wasting leakage. Send for the Free Fel-Pro Folder that shows a Packing for every purpose. 36 actual samples of sealing materials with application data. Also consult us on your difficult sealing problems. Felt Products Mfg. Co., 1535 Carroll Avenue, Chicago 7, Illinois

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East Ohio Gas Company has recently completed the final project in a vast expansion program to meet the mounting gas requirements of Ohio war industry. This is a 120-mile 20-inch pipe line which for the first time brings Texas-Kansas gas into the Ohio gas area, connecting at Maumee with the Panhandle Eastern line, from which it will take 50,000,000 cu. ft. of gas daily to meet increased demand requirements.

Surplus of this gas which occurs in periods of minimum demand will be repressured and pumped to storage wells by Robinson Station here pictured. It is powered with five 600 H. P.

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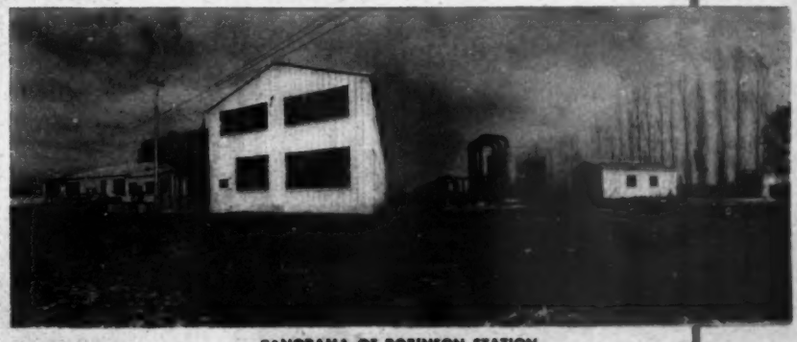
Power East Ohio Gas Company's New Robinson Station



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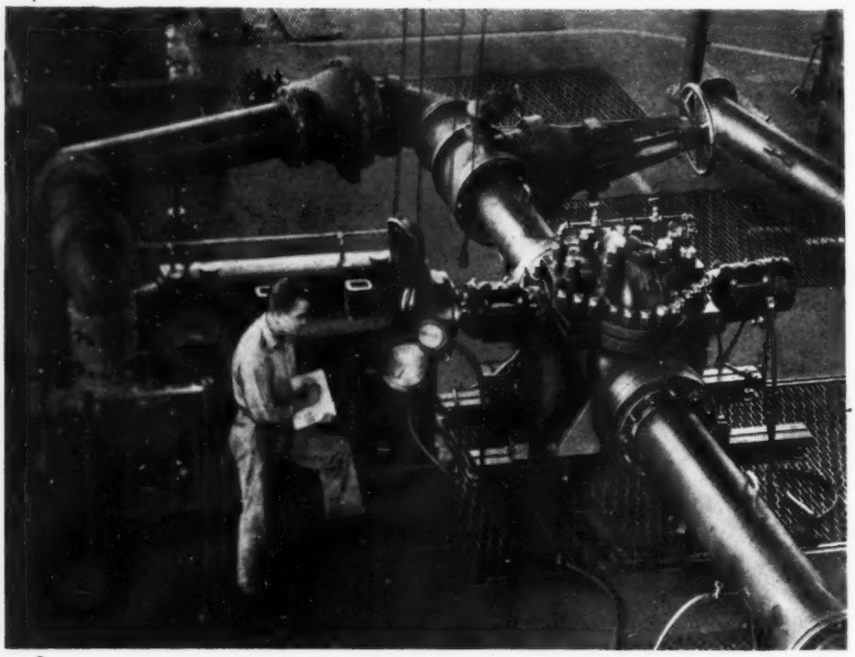


"Little Big Inch" pump on test bed at the manufacturer's works

PETROLEUM ENGINEER Exclusive Feature

by
Frank H. Love
Managing Editor

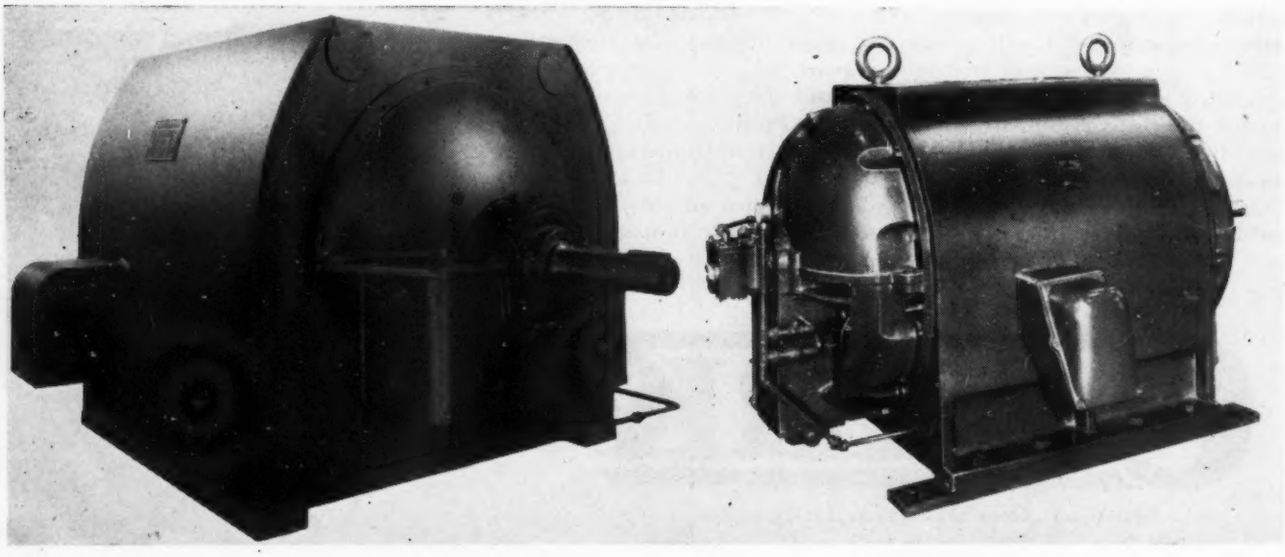
Station Operation and Equipment On WEP Products Line

Prime movers consist of 1250-hp. motors driving centrifugal pumps—Extensive use made of automatic controls

PUMPING equipment for War Emergency Pipelines' 20-in. products line from Beaumont, Texas, to the east coast was constructed similar to that installed on the 24-in. crude oil line, although a number of new and difficult problems involving efficiency and maximum reliability had to be solved before specifications were decided upon.

The pumps are single-stage, double-suction centrifugal units designed to operate in series of three, with each pump handling 6850 gal. per min. at heads ranging from 275 lb. or 875 ft. maximum, down to 208 lb. or 667 ft. based on a specific gravity of 0.72. As a normal design of pump having this capacity calls for a speed of not more than 1775 r.p.m., the speed of 3575 r.p.m. of these pumps is unprecedented.

Motors driving the mainline pumps are 1250-hp. units



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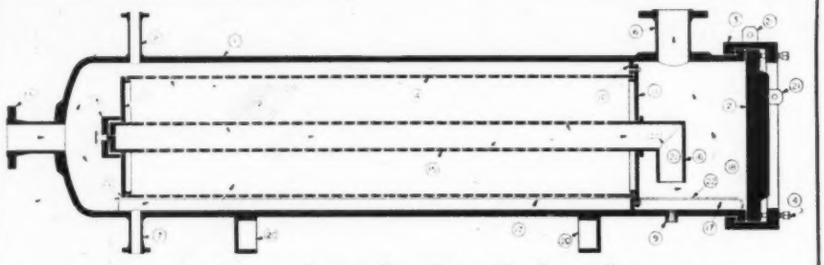
This operating speed has been found practicable, however, and was selected as it offered increased efficency of more than 3 per cent and a power saving of approximately $150,000 a year.

The pumps are designed so that two also may be operated in series or one may operate alone if that is desirable. With two pumps operating in series the line would deliver about 83 per cent of its rated capacity of 235,000 bbl. a day. With one pump operating alone delivery would be about 55 per cent of rated capacity.

All main line pumps are interchangeable insofar as mounting on the base plate, coupling, and nozzle locations are concerned, although individual detail designs were permitted the two manufacturers.[1]



Cross-sectional view of pipe line filter. Number references are: (1) welded steel shell. (2) cover. (3) Alco clamp ring. (4) compression bolting. (5) inlet nozzle. (6) outlet nozzle. (7) drain nozzle. (8) vent nozzle. (9) drain coupling. (10) basket retaining flange. (11) basket front end plate. (12) basket rear end plate. (13) yoke and tap bolt. (14) perforated basket screen. (15) perforated efflux pipe. (16) efflux pipe outlet elbow. (17) guide strips. (18) outlet channel. (19) filtering material. (20) support saddles. (21) lifting lugs. (22) non-ferrous facings.

Motors

Motors driving the mainline pumps are rated 1250 hp. at 3575 r.p.m., 2300 v. Although they are of the same type as the 1500-hp. motors on the "Big Inch" line, they differ from the latter principally in their higher rated speed and the use of a forced lubrication system.

Motors and pumps, of which there are three of each in a typical station, are separated by a fire wall to prevent passage of hazardous vapors from pump room to motor room. Motors and sole plates, which were supplied by three manufacturers,[2] have their mounting dimensions standardized for interchangeability.

The motors are of the open squirrel-cage type with sleeve bearings built into end shields, and with bearings and end shields both split to facilitate bearing dis-assembly. Fans built integral with the motor provide self ventilation. Cooling air enters at the ends and is discharged through an opening in the top of the motor frame, where it is picked up through ducts by exhaust fans and discharged into the pump or motor rooms or outdoors, according to room temperature requirements. This arrangement for ventilating the motors prevents recirculation of warm air through adjacent motors, as might be the case were the air discharged at the side of the motor. It also keeps the space between motors clear of air ducts. A 1-hp. exhaust fan is mounted in the ventilating duct above each motor.

The motor shaft extension is 12 in. in length and passes through a stuffingbox in the fire wall to the pump coupling. A shorter shaft extension than used on the "Big Inch" line was necessary to avoid critical speeds, and this required a special design of stuffingbox in the fire wall.

Motors are mounted on sole plates grouted into concrete foundation pedestals. The motors have a full load efficiency in excess of 95 per cent and the power factor is approximately 93 per cent. All motors are designed for starting at full voltage, although the reduced voltage starting method is used in nearly half of the 29 stations.

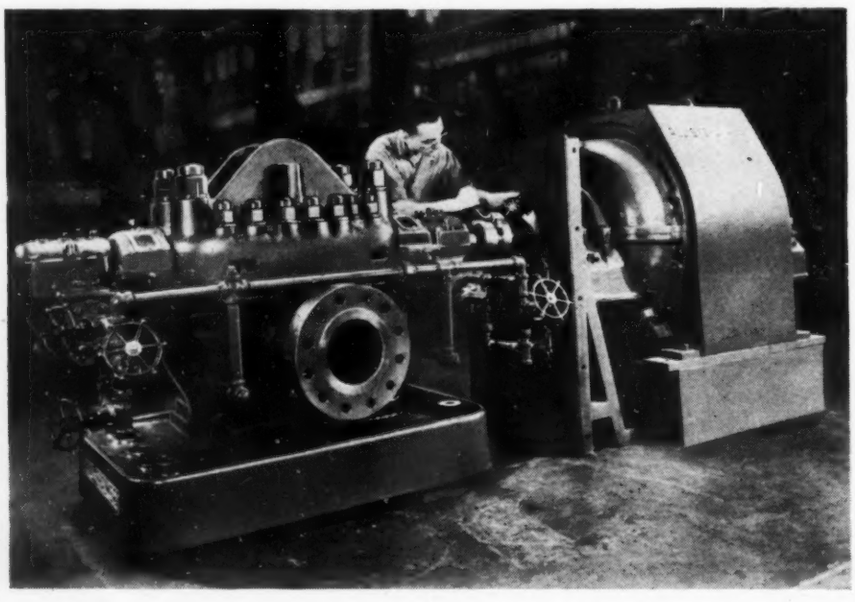
[1]Ingersoll-Rand Company and Allis-Chalmers Manufacturing Company.

[2]General Electric Company, Westinghouse Electric and Manufacturing Company, and Allis-Chalmers Manufacturing Company.

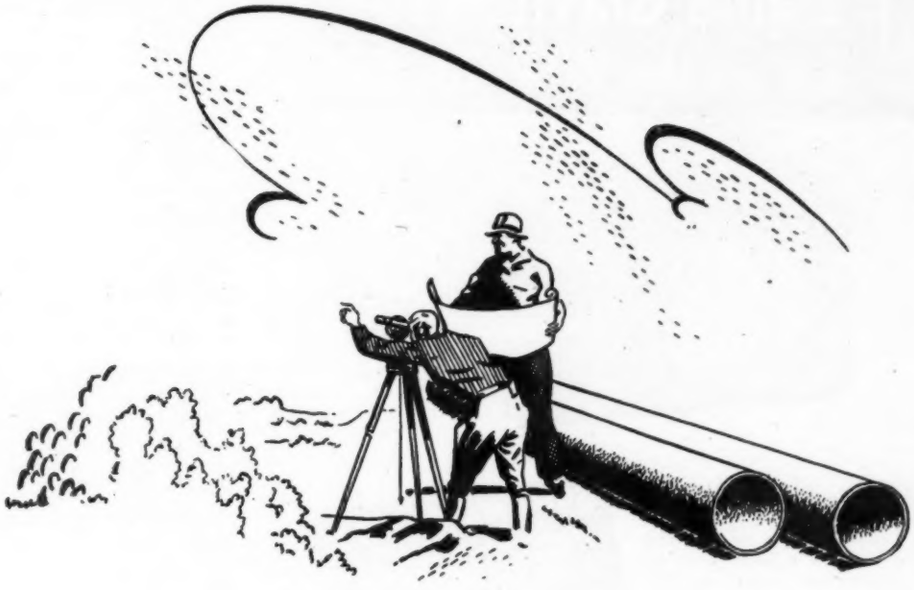
Station Control

Because great care must be exercised in pumping gasoline, a more extensive use of automatic controls is used in the pumping stations on the 20-in. line than on the 24-in. crude oil line. In each station there are three places where the operator can control its functions. Incoming power is controlled by switches at the switchgear panel, and the motors are started and stopped by push buttons on the control desk in the control room. Control switches on the motor switchgear panels in the same room are available to stop the motors, but must be in the "remote" position before the motors can be restarted at the control desk. In the pump room there are "stop-run" push buttons for each unit and these must be in the "run" position before the motors can be restarted at the control desk.

Closing the "start" push button for each pumping unit initiates an automatic starting sequence that cannot function, however, unless all protective devices register normal conditions, and the suction valve is fully open and the discharge valve closed. Then the ventilating fan motor starts simultaneously with the motor that opens the suction valve. When the valve is fully open the switchgear is automatically energized to start the main motor. When the motor is connected directly to the power circuit at full voltage the motor-operated discharge valve begins to open. As the discharge valves are of the plug type, with considerable overlap, the main motor reaches full speed before the valve is opened very far.



A pump and motor being arranged in combination on the assembly floor by one manufacturer before shipment



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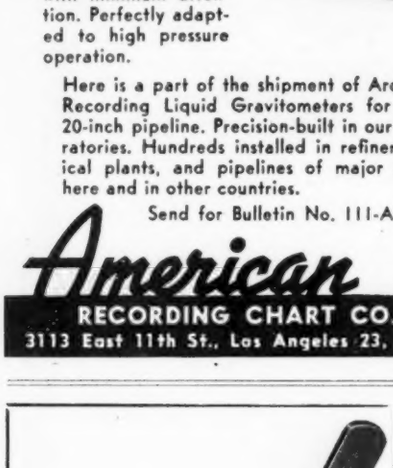

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When the main pump motor is stopped, the ventilating fan motor is automatically shut down and the suction and discharge valves returned automatically to their initial positions. If power fails, this automatic return of the valves to original positions occurs when normal voltage returns.

Protective Features

Many automatic protective features are provided. An alarm is sounded, red indicating lamps on the control desk are lighted, and the corresponding circuit breakers are tripped in case of high pump or downstream line pressures, low station suction head, high temperatures of motor bearings, pump bearings or pump casings, or abnormally high incoming line or motor amperes. In case of low voltage, the circuit breakers will be tripped after an automatic time delay to eliminate momentary dips in voltage. In case of low air pressure for the pressure regulators, high motor stator temperature, or a high level in the sump that collects leakage past the pump glands, an alarm will be sounded automatically and a corresponding red light will show on the control desk, but no automatic shutdown of equipment will occur, as these are conditions that may not require such action.

When high pump pressure occurs, the protective switch starts a sequential shutdown of the main pumping units. First, the last unit on the downstream side is stopped. If this does not give sufficient relief, the next unit is automatically stopped after a time delay of a few seconds, adjustable from one-half to four seconds. If the abnormal condition still persists, the third unit is shutdown after a similar time delay. Progression of this sequential action ceases as soon as the pressure is sufficiently reduced, and thus one or two of the pumping units may continue to operate. All units thus taken out of service must be restarted by the station operator.

In case of low station suction head, a protective pressure switch shuts down the entire station. The same thing occurs if the line pressure on the downstream side of the station reaches too high a point.

In general the electric control scheme for the pumping stations has been kept relatively simple by confining the automatic features to functions that the pipe line engineers considered necessary to insure proper care in handling gasoline. There are no electric control connections between pumping stations, because all necessary interrelated operations can be governed in accordance with pressure conditions in the line.

Control Desk

A feature of each station is the control desk. This desk was designed by

Westinghouse engineers, is waist high and about 8 ft. long. It has a semi-transparent plastic top section on which is imprinted a diagram of the station, showing each motor, pump, valve, and pipe.

Underneath the plastic top are 60 tiny electric lamps colored red, green, or amber. A maze of wires connects the lamps to valves, thermometers, and pressure gauges situated at strategic points in the station piping, in motors, and on bearings.

If a pump develops an abnormal temperature or pressure a red light flashes on to show on the diagram the location of the trouble. The same thermostat or pressure relay that turned on the tell-tale lamp also operates protective devices that automatically stop the electric motor and close the valves leading into the sump, causing other valves to open, rerouting the fuel around the idle unit.

The desk fits into a control room window that permits the operator a clear view into the motor room and pump room.

Filters

Pipe line filters, or what is sometimes popularly termed "hay tanks," have been provided to remove foreign materials from products before they enter the pumps. Failure to do so results in damage to valve seats, pumps, meters, etc.

The type of filter installed[3] provides maximum filtering capacity by reducing the velocity of the liquid upon its entrance into the filter. The shell space at the incoming end and around the perforated basket screen provides sufficient area for the heavier solids to drop out and deposit at the bottom of the shell, before the liquid contacts the filtering media in the basket. Also, by directing the flow through the filter from the outside of the basket to the efflux pipe in the center, initial contact with the filtering media is made where its area is the maximum.

Time offstream due to recharging is minimized by the method of the filter's construction. Bolts in the two-piece clamp ring for attaching the cover plate can be readily backed out far enough for the clamp to clear the beveled groove in the shell flange, the bolts remaining in the clamp ring. The clamp ring and cover plate are then removed, tap bolts backed out of the basket retaining flange, and the basket withdrawn. A spare filter basket, packed and ready for use, can then be inserted, or if not available the basket refilled with filtering material. Drop in pressure indi-

[3]Manufactured by Alco Products Division of American Locomotive Company.

(Continued on Page 198)

Portable pipe lines, composed of 20-foot sections easily handled by one man, followed our advancing forces across the desert. The wide range of Naylor Pipe sizes from 4" to 30" in diameter makes this pipe ideal for numerous post-war applications in the oil fields.

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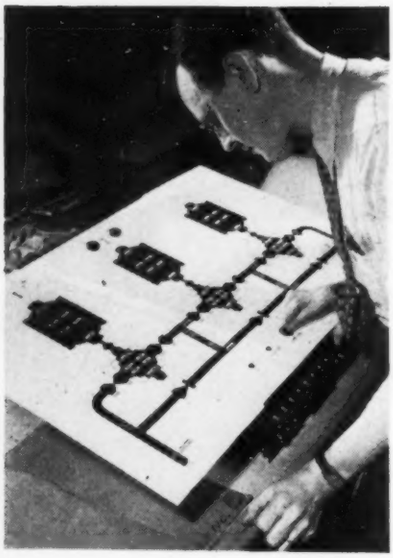


Working model of control desk

(Continued from Page 195)

cates when a change of the filtering media is required.

An elbow at the outlet of the efflux pipe directs the filtered products downward, thereby minimizing short-circuiting of the flow to the outlet nozzle. The resulting agitation, especially at the bottom of the channel, reduces the contamination time on a products line installation.

Dispatching

Gravitometers[4] that record the specific gravity of a small continuously flowing sample of the liquid being pumped are the basis for dispatching the several products handled by the line. In general the instrument is a spring balance recording the dead weight of a fixed volume of the liquid in terms of specific gravity.

The following is an outline of the liquid flow through the instrument and the manner in which the weight of the liquid is utilized to actuate the mechanism.

The closed liquid system consists principally of a bulb, inlet tube, and outlet tube. These tubes, which conduct the liquid into and out of the bulb, serve also as the spring elements of the weighing mechanism. The liquid in the bulb constitutes the principal volume being weighed. The bulb is suspended by suitable links and fulcrums at the left end of the main beam. At the opposite end of the beam is a counterweight as well as a vernier weight used for adjustment purposes. This counterweight balances the dead weight of the bulb as well as the dead weight of the liquid in the bulb when the liquid is of a specific gravity equal to the minimum range of the chart scale.

As the liquid passing through the tubes and bulb becomes heavier, or increases in specific gravity, the bulb descends, its descent being resisted by the spring action of the inlet and outlet spring tubes. This motion of the bulb is directly proportional to the changes in the specific gravity of the liquid passing through the bulb. The motion of the bulb is transmitted to the main beam through supporting links, bulb support beam, and support beam knife link, causing the main beam to move on its supporting links, rising and descending in proportion to the changes in specific gravity of the flowing sample.

A floating lever, supported at its center fulcrum by the thermostatic connecting rod, is moved by the main beam through the connecting rod about the center fulcrum pin of the floating lever. Two pivot screws in the pen shaft arms support the opposite end of the floating lever. The motion of the floating lever is transmitted to the pen shaft through these arms and from the pen shaft to the pen arm attached to the outer end of the pen shaft. All calibration to the chart scale is accomplished by proper positioning of the connections to the floating lever.

The thermostatic coil assembly is immersed in the flowing sample of liquid. After passing through the bulb, liquid passes through the thermostatic coil body. Under the influence of temperature changes of the liquid, the thermostatic coil actuates the thermostat arm, and through the connecting rod the floating lever.

The thermostatic coils are individually rated and the length of the arm is adjusted so that the floating lever is moved about its right hand pivot end sufficiently to move the pen arm through a lever to compensate the chart record for the changes in specific gravity due to temperature changes alone. This adjustment is based on the coefficient of expansion of the average liquid handled through the instrument.

The instrument has a temperature compensation element so that the specific gravity as recorded upon the chart is the specific gravity of the liquid at 60°F., even though the temperature of the liquid in the line or passing through the instrument may vary widely from 60°F.

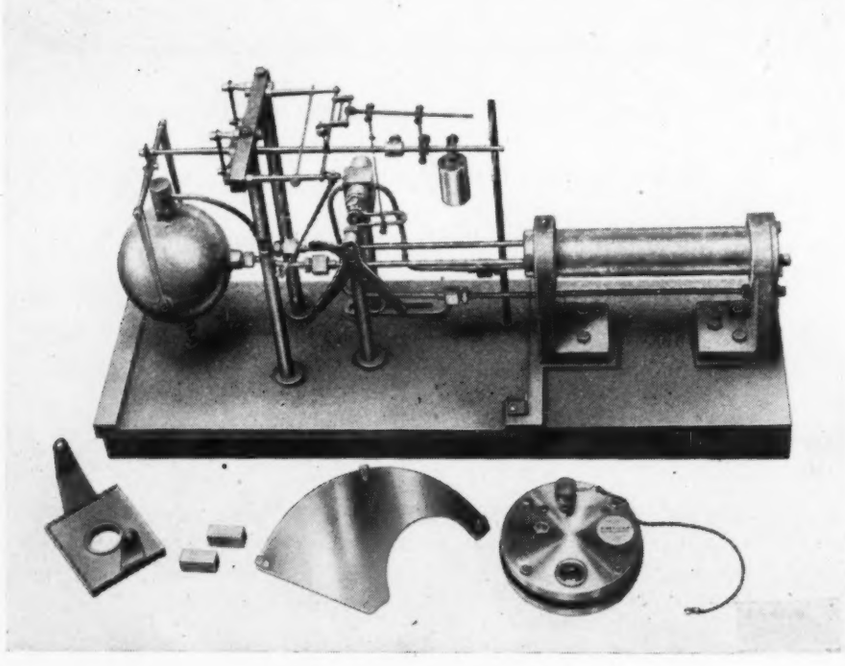
——— ☆ ☆ ☆ ———

[4]Manufactured by American Recording Chart Company.

First Products Reach East

The first batch of products—95,000 bbl. of gasoline — arrived on the East Coast through the "Little Big Inch" pipe line, reaching the Linden, New Jersey, terminal at 4:56 p. m. March 2. The first heating oil arrived two days later, March 4, at 5:00 a. m.

The "Little Big Inch" is the fifteenth pipe line project to begin actual operation under PAW's overland transportation program to speed petroleum and petroleum products from the Southwest and Midwest to the consuming areas on the Atlantic Seaboard.



Temperature-compensated recording liquid gravitometer with case, chart plate, and clock removed

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P 615.51

Electrical Sinews For WEP Products Line

☆ **Station design of products line and "Big Inch" differs principally in system of control**

by M. A. Hyde, Industry Engineer,

Petroleum and Chemical Section, Westinghouse Electric & Mfg. Co.

THE 20-in. refined products line from Beaumont, Texas, to the Philadelphia and New York areas is now completed.

Called "Little Big Inch" because it's a trifle smaller in the waist, it is 150 miles longer than its companion line, the "Big Inch," and it really packs a bigger wallop than the latter, for its 235,000 bbl. per day capacity of refined products represents the equivalent of some 370,000 bbl. per day of crude oil.

Little Big Inch, drawing products from 10 refineries in the Baytown and Beaumont areas, runs 350 miles to Little Rock, Arkansas, where it joins the right-of-way of the 24-in. line and follows it from there on to the East. Beginning at little Rock the 20-in. line stations are at the same sites as the stations on the 24-in. line. Thus substantial savings are effected in costs of right-of-way, the station sites, power procurement, energy, operating labor, and operating maintenance.

Station layout on the 20-in. line, as indicated by Fig. 1, is quite similar to that of the 24-in. line; however, the handling of refined products entails the addition of filter units.

Power service facilities are entirely similar to those of the 24-in. line. Transformers of 3750 kva. rating are installed, the two transformers at each site operating in general from a common primary bus with independent secondary circuits to the respective pump houses.

Ultimately it is likely that a 2300 v. bus tie will be installed with a normally open switch. Upon failure of either of the transformers, closure of this bus tie would permit both stations to be loaded from one transformer, which, cooled by air blast, would permit operation of selected units in both stations.

Main switchgear for the 20-in. line stations is interchangeable with that of the 24-in. line. An additional matching unit houses the station sequency control, to be described later.

Pumping Units

The three pump units are driven by 1250-hp. motors at 3575 r.p.m., similar to the 24-in. line motors in ventilation arrangement. Fig. 2 is a shop view showing the motor construction, a principal feature being the provision of flood lubrication by a shaft-driven oil pump. Like the 24-in. line motors, these units are coordinated in respect to mounting dimensions, so that all main pump motors on the 20-in. line are mechanically interchangeable regardless of manufacture.

The pumps are single stage, 14 by 12, operating 3 units in series to handle 235,000 bbl. per day of gasoline developing a total pressure of approximately 750 lb. per sq. in.

Station Control

The principal differences in the 24-in. and 20-in. station designs lie in the system of station control, occasioned largely by the greater precision justified in products line operation to minimize contamination between products. The suction and discharge valves of each pump are motor operated, and the complete pumping unit, with valves, is controlled by a single "start-stop" push button.

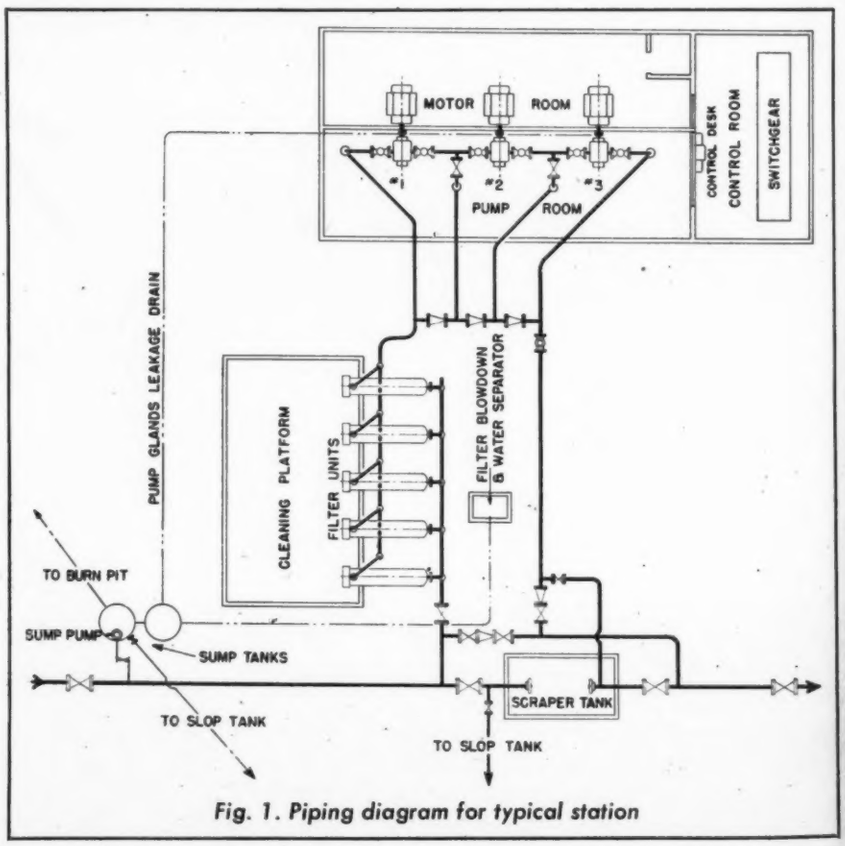
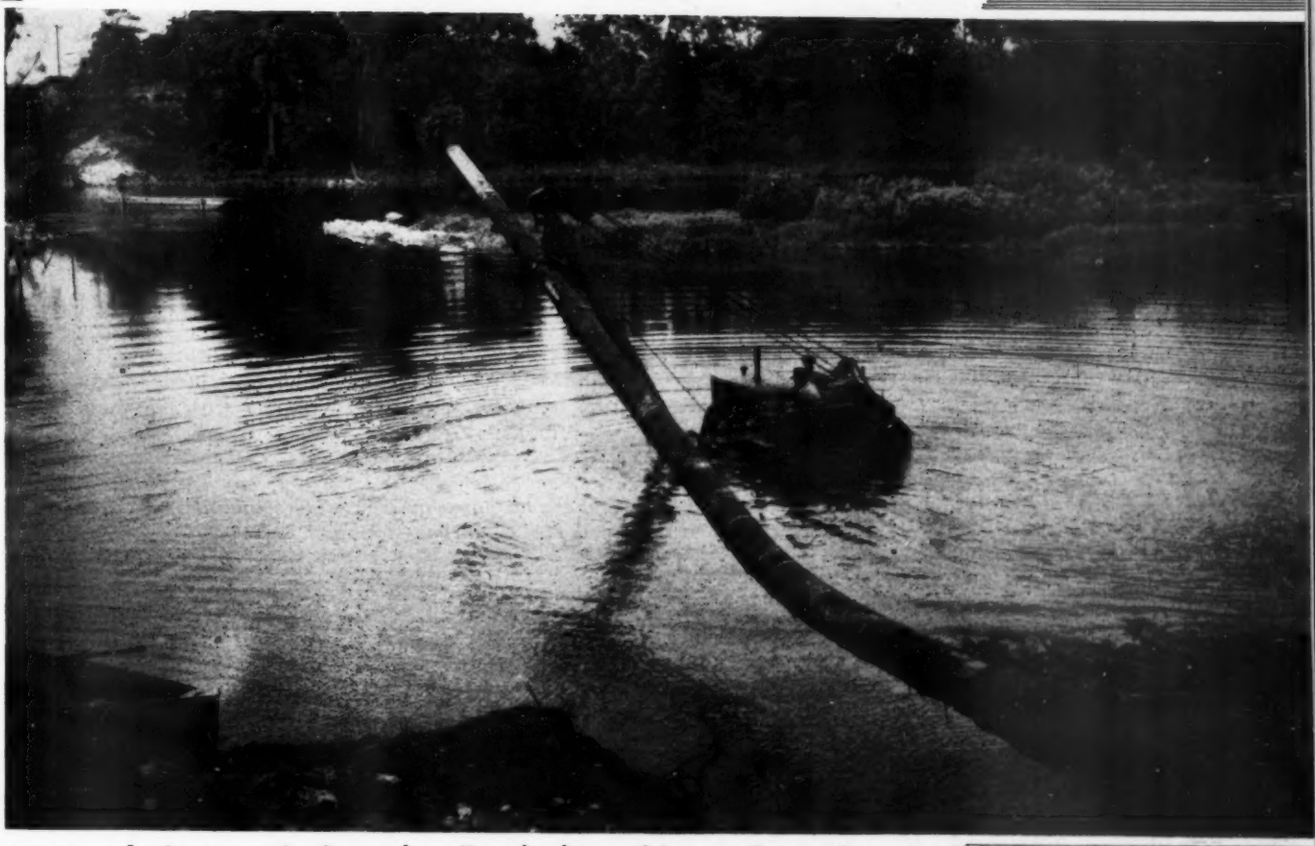


Fig. 1. Piping diagram for typical station

This article is part of a paper presented before meeting of American Institute of Electrical Engineers in New York City.

WE MEET AND BEAT SCHEDULES



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Protective relays actuated by pressure and temperature are used somewhat more extensively in the 20-in. line stations. In addition to low station suction pressure and high station discharge pressure protection, there is a pressure relay connected immediately upstream of the station throttling control valve. If excessive pressure occurs at this point, this relay stops whichever unit is operating as the final unit in the station, and if pressure conditions are not restored to normal within some 3 sec. then it proceeds to stop the next unit in timed sequence, and finally, if abnormal pressure still persists, it stops the remaining unit.

Temperature-actuated relays are employed in all pump casings, pump bearings, motor bearings, and on the motor windings.

Fig. 3 shows the method of installing the pressure and temperature protective relays associated with equipment in the pump room. It will be noted that each relay is in an explosion-proof housing.

In general each protective relay actuates circuits to perform three functions:

(1) Sound an alarm.

(2) Energize an indicating light to identify the protective device that operated.

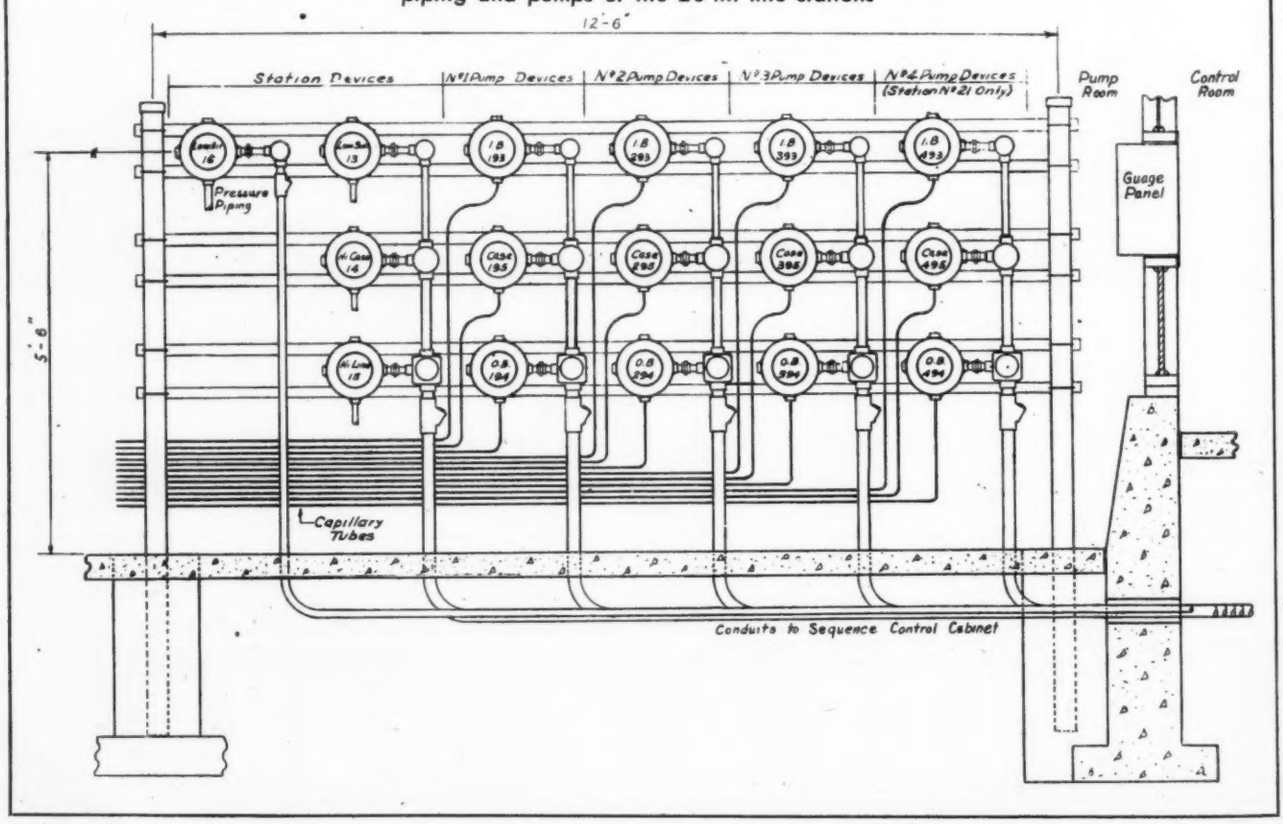
Fig. 2. Shop view showing motor construction

(3) Stop the unit or the station. Certain relays provide alarm and light signal only, leaving corrective action to the operator. This is true in the case of high temperature in motor windings, high level in the pump to which gland leakage is drained, and low air supply to the pressure controllers.

The scheme of control for performing these functions is shown in Fig. 4. Due to the unusual interest in this control, this drawing, of more than usual detail, is included.

A feature in line with recent practice on other products pipe lines is the provision for throttling at the station discharge under automatic control by pneumatic controllers. This system is designed to throttle the station discharge when necessary to maintain the station suction pressure above a predetermined low limit, say 30 lb. per sq. in., or to maintain the line pressure beyond the station discharge below a predetermined pressure, say 800 lb. per sq. in. This system is also useful in bringing pumping units onto the line, as it provides regulation of the maximum station discharge pressure to the discharge control instrument setting. When placing a unit in service, this setting can be adjusted readily to limit the effective station increment pressure initially to substantially the value that existed before starting the unit. Then the station increment can be raised gradually by reduction in throttling, thus making the additional pump pressure effective on the line with minimum hydraulic dis-

Fig. 3. These protective relays, some actuated by pressure and others by temperature, guard strategic points in the piping and pumps of the 20-in. line stations



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turbance. This procedure avoids shutdowns during starting operations, that otherwise might result from pressures exceeding the allowable range with consequent functioning of the protective relays.

Station Control Desk

Nerve-center for all these control operations and protective functions is the station control desk and the associated sequence control cabinet. Fig. 5 shows how the several circuits from the pump and motor rooms — from the lock-out push-buttons, the motor operated valves and the protective pressure and thermal relays — all converge in the station sequence control cabinet. In it are assembled the necessary relays to translate the incoming impulses into proper action by the switchgear, valves, auxiliary blower controls and, when necessary, the station alarm. At the same time the station sequence control equipment sets up proper circuits to the control desk to keep the operator informed by indicating lights regarding the functioning of the various apparatus.

The station control desk is shown in Fig. 6. From here all major operations of station control are performed. This desk, installed in the partition between the control room and the pump room, is surrounded by a large glassed area permitting view of the pump room and motor room. To facilitate this view the gauge panel section is designed low, so that the operator can look over the top of the unit.

The gauge panel section consists of a compartment having rear doors opening into the pump room to permit servicing the hydraulic instruments. The front is

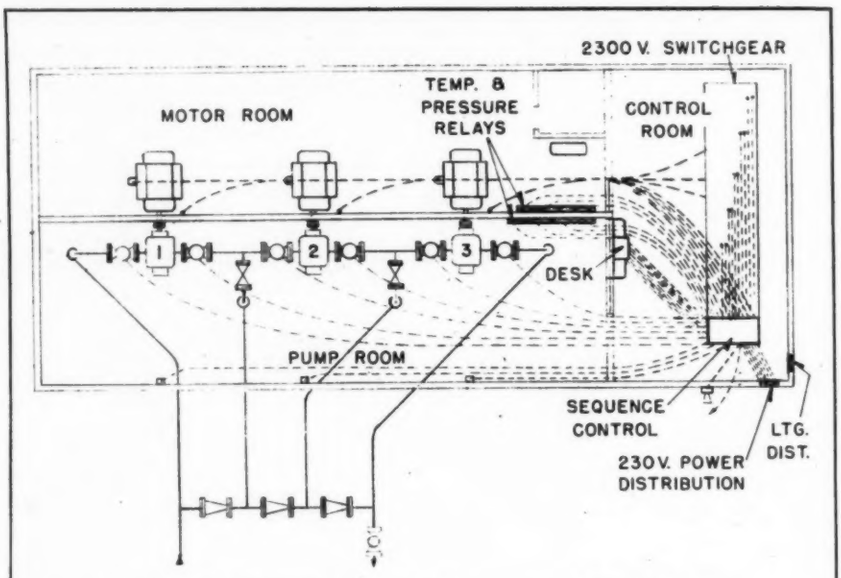

Fig. 5. Typical conduit layout for power and control wiring in products line station

Fig. 4. Schematic diagram of station sequence control for 20-in. products line, 3-unit station, using reduced-voltage starting. Except for those devices shown in broken lines, the main switchgear is not included in this diagram

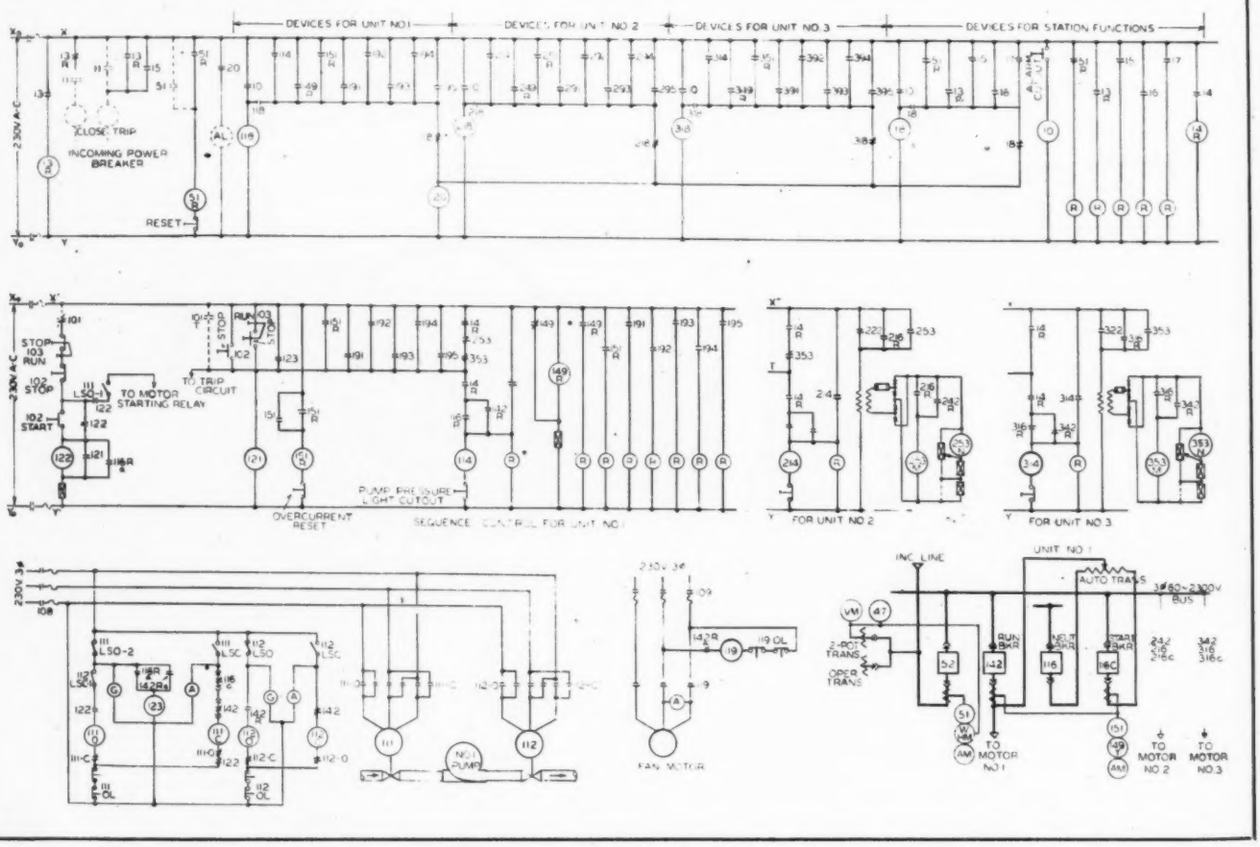

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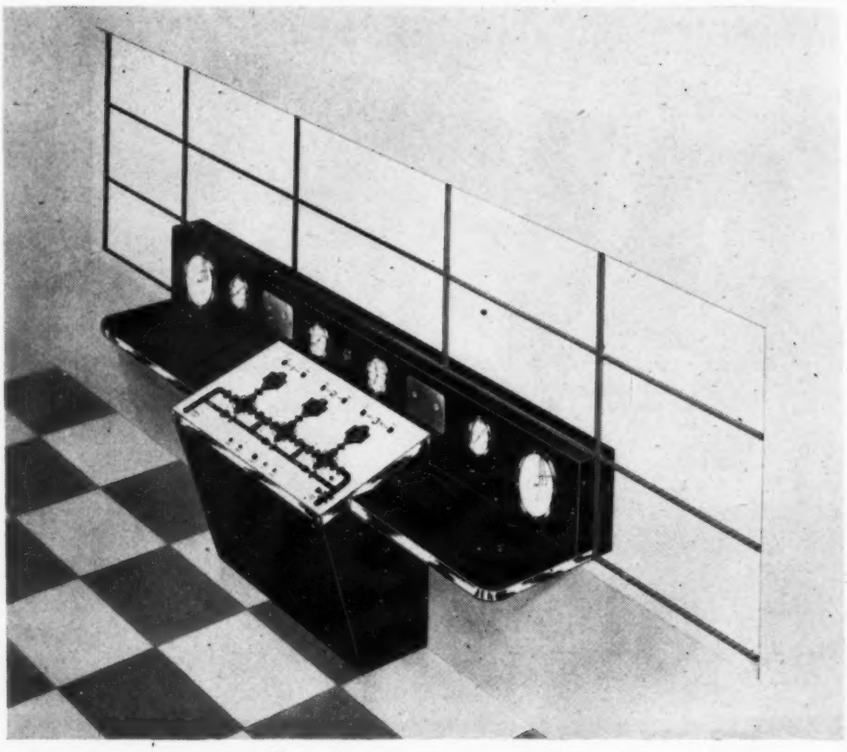
Fig. 6. Design drawing of control desk



a panel surface facing the control room, on which the instruments are mounted with gaskets. This gauge panel compartment is gasketed into the partition to prevent seepage of hazardous vapors into the control room, and as an additional precaution, the control room is kept under a small pressure of clean air drawn from the outside of the building.

Instrumentation consists of: (1) Suction pressure controller and recorder; (2) suction pressure indicating gauge; (3) pressure gauge for air to pneumatic controllers; (4) air pressure regulator adjusting valve; (5) clock; (6) discharge pressure indicating gauge, and (7) discharge pressure controller and recorder.

A horizontal surface below and at each end of the gauge panel provides writing space and accommodates the station log sheet.

The electrical section of the control desk is a separate unit isolated from the gauge panel compartment, situated entirely within the control room, mounting push buttons and indicating lights for the master station control. The desk top surface is a sheet of transparent plastic, backed with a schematic design of the main piping within the station, and showing the main line valves, pumps, and driving motors.

From a single start-stop push button the operator controls each pump unit, the valve motor control and pump motor control automatically functioning in proper sequence for starting up and shutting down. Indicating lights in the desk top diagram show the valve positions, and small illuminated arrows show the actual course of the stream through the station piping in accordance with the particular units operating. A close-up view of the desk top is shown in Fig. 7.

If trouble should develop at any of the protective device locations, a small red indicating lamp appears at the appropriate spot in the station diagram, and the operator is given an audible signal. In addition, certain of the protective devices automatically shut down the particular unit involved, or the station. In each case, the audible signal continues until it is silenced by an alarm out-out button, and the particular indicating light burns to tell the operator exactly where the trouble is until extinguished by manual reset at the protective device location, when the trouble is cleared.

This desk and the associated system of control greatly simplify the duties of the station attendant, increase the reliability of station operation, and facilitate location of the trouble spot in case of abnormal shutdown. Checking continuously the pulse and the temperature of the station equipment, the desk has been called appropriately, "pipe line nurse."

The building of the world's two largest pipe lines in a little over two years is a tremendous task. It is tremendous in tonnage of materials, in distances, and terrain, and in the coordination of work and supplies. To have accomplished these things in the time involved, is indeed a tribute to the oil industry, its engineers and all associates. The electrical industry is proud that within the time prescribed it could cooperate and coordinate its activity with the broad requirement of the oil industry, not only to supply the prime power, but also to assist in the perfection of control that has contributed and will contribute so greatly to the performance of the job.

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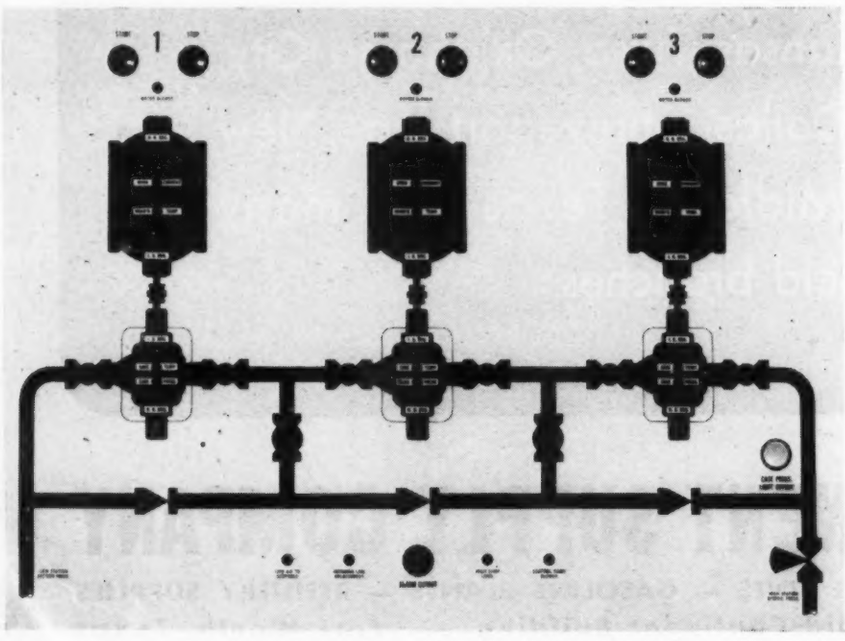

Fig. 7. Top of control desk

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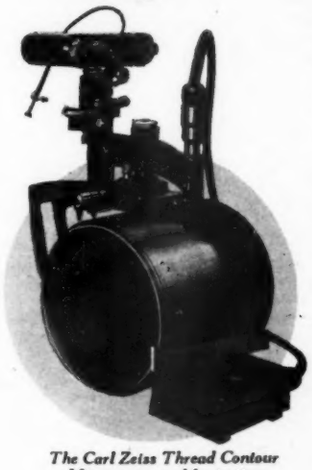

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Corrosion of Buried Metals And Cathodic Protection

PETROLEUM ENGINEER Exclusive Feature

☆ A discussion of what causes corrosion and how it is reduced by cathodic protection

by M. C. Miller

Electrical Engineer, Ebasco Services Incorporated

CORROSION of buried metal is the result of electric current flowing from the metal into the adjacent soil. When current flows from the metal into the soil, it carries minute particles of the metal with it. This commonly is referred to as corrosion or electrolysis.

Current may be produced at the surface of the metal, being the result of chemical action between the metal and the chemicals in the soil contacting it, in which case the corrosion is referred to as galvanic corrosion; or the current may be stray current from an electric railway system, and the corrosion referred to as electrolysis. (See Fig. 2).

This article was planned by the writer to present in a simple way the theory of galvanic corrosion of pipe lines and other buried metallic structures. Emphasis has been placed on fundamentals, as it is believed that an understanding of these essentials is an approach to solving corrosion problems.

Corrosion of metals in soil falls into two general classifications: (1) galvanic corrosion, and (2) electrolysis. The discussion in this article deals primarily with galvanic corrosion.

Corrosion of metal occurs where current flows from the surface of the metal into soil, whereas no corrosion takes place in the areas where current flows from the soil to the metal.

This current is direct current, such as is obtained from dry cells, flashlight batteries, storage batteries, and rectifiers; also as used by street railway systems. So far as is known, no appreciable corrosion is caused by flow of alternating current generally used for home, commercial, and industrial lighting and power.

This article contains a discussion of galvanic corrosion such as occurs on buried pipe lines, lead-sheath cables, well casings, tank bottoms, conduits, and many other metal structures buried in soils or submerged in water or other solutions.

Galvanic Corrosion

The fundamental causes of galvanic corrosion are simple. If two different metals, say a galvanized pipe and a black iron pipe, buried in a moist soil are metallically connected together, an electric current will flow, as indicated in Fig. 1. The arrows show the direction of current flow—from the galvanized pipe into the soil, through the soil to the black pipe or steel pipe, and through the metallic connection back to the galvanized pipe.

This electric current is the result of chemical action between the surfaces of the pipes and the chemicals in the soil. This current flow dissolves the zinc (which is the galvanizing on the surface of the pipe) and it mixes with the soil. This action may continue until all the zinc is gone or corroded away.

This same chemical action is the basis of the common dry cell or dry battery, as shown in Fig. 3. Zinc, which is the same metal as used for galvanizing the surface of a pipe, is used for a container. A carbon rod is placed in the center and the space between the two packed with

M. C. MILLER

has had 27 years' engineering experience, principally on electrical distribution system design and operation in New York, Minnesota, and Texas—Has been with Ebasco Services Incorporated, New York City, last 7 years on general electric engineering duties—Has worked on corrosion and cathodic protection on pipe lines and distribution systems for last 5 years—Last 2 years he has devoted virtually full time to corrosion and cathodic protection studies, investigations, design, installations, and operation—Is a member of National Association of Corrosion Engineers.

Fig. 1. Galvanic corrosion

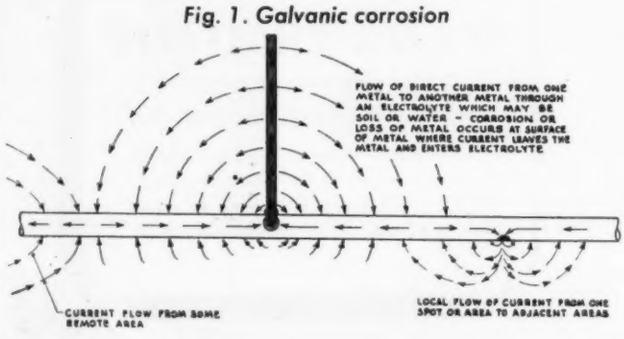
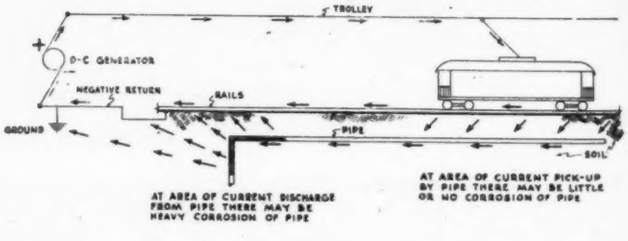

FLOW OF DIRECT CURRENT FROM ONE METAL TO ANOTHER METAL THROUGH AN ELECTROLYTE WHICH MAY BE SOIL OR WATER - CORROSION OR LOSS OF METAL OCCURS AT SURFACE OF METAL WHERE CURRENT LEAVES THE METAL AND ENTERS ELECTROLYTE
CURRENT FLOW FROM SOME REMOTE AREA
LOCAL FLOW OF CURRENT FROM ONE SPOT OR AREA TO ADJACENT AREAS

Fig. 2. Electrolysis

General note: Shaded areas indicate areas where metal will corrode.


TROLLEY
D-C GENERATOR
NEGATIVE RETURN
RAILS
GROUND
PIPE
SOIL
AT AREA OF CURRENT DISCHARGE FROM PIPE THERE MAY BE HEAVY CORROSION OF PIPE
AT AREA OF CURRENT PICK-UP BY PIPE THERE MAY BE LITTLE OR NO CORROSION OF PIPE

Holding 7,500 Pounds Pressure

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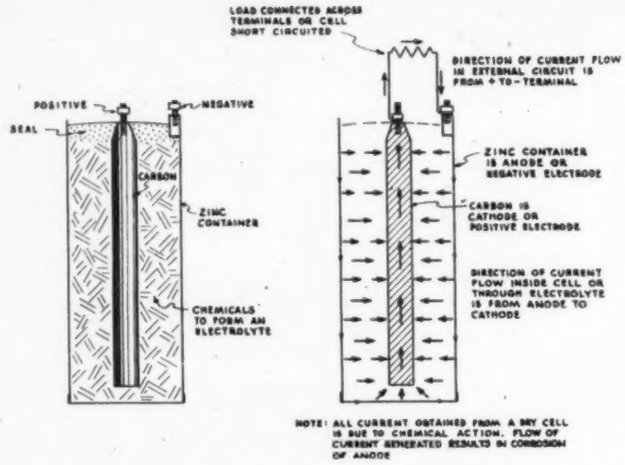
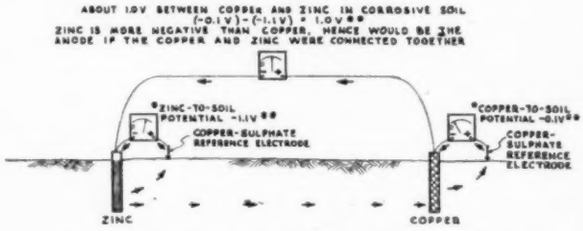

LOAD CONNECTED ACROSS TERMINALS OR CELL SHORT CIRCUITED
DIRECTION OF CURRENT FLOW IN EXTERNAL CIRCUIT IS FROM + TO − TERMINAL
POSITIVE
NEGATIVE
SEAL
CARBON
ZINC CONTAINER
CHEMICALS TO FORM AN ELECTROLYTE
ZINC CONTAINER IS ANODE OR NEGATIVE ELECTRODE
CARBON IS CATHODE OR POSITIVE ELECTRODE
DIRECTION OF CURRENT FLOW INSIDE CELL OR THROUGH ELECTROLYTE IS FROM ANODE TO CATHODE
NOTE: ALL CURRENT OBTAINED FROM A DRY CELL IS DUE TO CHEMICAL ACTION. FLOW OF CURRENT GENERATED RESULTS IN CORROSION OF ANODE

Fig. 3 (far left)—Basic design of dry cell

Fig. 4 (left)—Direction of current flow in dry cell

Fig. 5 (below)—Half-cell potential of metals and potential between two metals


ABOUT 1.0V BETWEEN COPPER AND ZINC IN CORROSIVE SOIL
(−0.1 V) − (−1.1V) = 1.0V **
ZINC IS MORE NEGATIVE THAN COPPER, HENCE WOULD BE THE ANODE IF THE COPPER AND ZINC WERE CONNECTED TOGETHER
*ZINC-TO-SOIL POTENTIAL −1.1V **
COPPER-SULPHATE REFERENCE ELECTRODE
*COPPER-TO-SOIL POTENTIAL −0.1V **
COPPER-SULPHATE REFERENCE ELECTRODE
ZINC
COPPER

*HALF-CELL POTENTIAL TO SOIL USING REFERENCE ELECTRODE. SKETCH SHOWS ACCEPTED PRACTICE OF CONNECTING VOLTMETER FOR CORROSION AND CATHODIC PROTECTION TESTS ON PIPE LINES AND MANY OTHER METAL STRUCTURES. PRACTICES DIFFER ON LEAD SHEATHED CABLE.

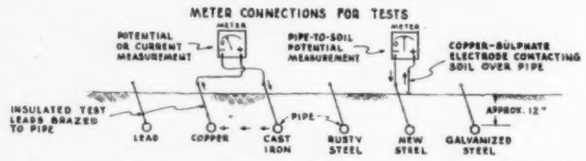
**PIPE-TO-SOIL POTENTIALS FOR ANY PARTICULAR METALS AND DIFFERENCE IN POTENTIAL BETWEEN ANY TWO METALS WILL VARY OVER A WIDE RANGE IN DIFFERENT TYPES OF SOILS. GENERALLY, THE MORE CORROSIVE THE SOIL, THE MORE* NEGATIVE THE POTENTIAL OF METAL.

chosen chemicals. When a wire or lamp is connected between the zinc and the carbon, an electrical circuit is made and chemical action causes current to flow from the zinc into the chemicals, through the chemicals to the carbon, and through the wire or lamp back to the zinc. (See Fig. 4) The flow of electric current from the zinc to the chemicals carries particles of zinc with it, or as is commonly said, the zinc corrodes, and when it is practically corroded away, little or no current is generated and the dry cell or battery usually is thrown away.

When any two buried metals, which are not of the same kind of metal, are connected together with a wire, or by welding or coupling, or even in accidental contact so that a path is provided for electric current to flow, one of them will tend to corrode. Fig. 7 shows some of the combinations of metals commonly used for buried pipe lines, lead-sheath cables, copper ground wires and rods, and other buried structures. The metal that will corrode, and the direction of

Fig. 6 (below)—Test installation in corrosive soil, potential measurements

Fig. 7 (right)—Test installation in corrosive soil, current measurements



POTENTIAL MEASUREMENT OF EACH PIPE TO COPPER PIPE AND OF EACH TO REFERENCE ELECTRODE (COPPER-SULPHATE OR $CuSO_4$ ELECTRODE)

KIND OF PIPE	SIZE OF PIPE	APPROX. AREA OF PIPE	POTENTIAL TO COPPER	PIPE-TO-SOIL POTENTIAL USING $CuSO_4$ ELECTRODE	DIFFERENCE
GALVANIZED STEEL	2" O.D. X 12'	7.5 SQ. FT.	−.86 VOLTS	−1.08 VOLTS	.94 VOLTS
NEW STEEL	" " "	" " "	−.52 "	− .74 "	
RUSTY STEEL	" " "	" " "	−.32 "	− .54 "	
CAST IRON	2½" O.D. X 12'	8.0 " "	−.36 "	− .57 "	
COPPER	2" O.D. X 12'	6.6 " "	.00 "	− .21 "	
LEAD	1¼" O.D. X 10'	4.0 " "	−.355 "	− .565 "	

CURRENT MEASUREMENTS BETWEEN VARIOUS DISSIMILAR METALS AND CALCULATED LOSS OF METAL PER YEAR. (SEE FIG. 6 FOR PIPE INSTALLATION AND METER CONNECTIONS)

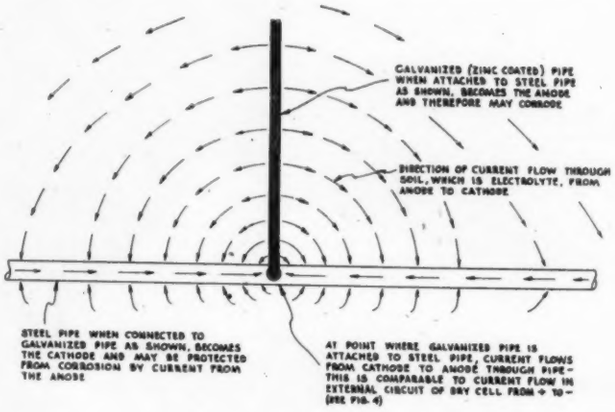
KINDS OF PIPE CONNECTED AND DIRECTION OF CURRENT FLOW	POTENTIAL DROP ACROSS 10 OHM RESISTOR*	CURRENT FLOW	CALCULATED YEARLY LOSS OF METAL**
GALVANIZED STEEL → NEW STEEL	.16 VOLTS	.016 AMP	.32 LBS.
NEW STEEL → RUSTY STEEL	.10 "	.01 "	.20 "
RUSTY STEEL → CAST IRON	.02 "	.002 "	.04 "
CAST IRON → COPPER	.175 "	.0175 "	.35 "
COPPER → LEAD	.14 "	.014 "	.28 "

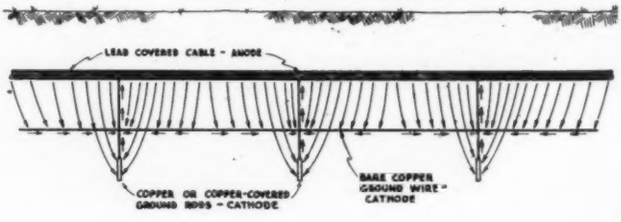
*IF LESS RESISTANCE HAD BEEN USED WHEN MEASURING CURRENT, VALUE OF CURRENT WOULD HAVE BEEN GREATER.

**POUNDS OF METAL LOST IN YEAR BASED ON ASSUMPTION THAT ONE AMPERE FLOWING FROM METAL TO SOIL CARRIES AWAY 20 POUNDS OF METAL PER YEAR. (.70 LBS. PER AMPERE PER YEAR FOR LOAD)

Fig. 8 (left)—Direction of current flow between dissimilar metals in soil

Fig. 9 (below)—Corrosion of lead cable sheaths caused by dissimilar metals in soil


GALVANIZED (ZINC COATED) PIPE WHEN ATTACHED TO STEEL PIPE AS SHOWN, BECOMES THE ANODE AND THEREFORE MAY CORRODE
DIRECTION OF CURRENT FLOW THROUGH SOIL, WHICH IS ELECTROLYTE, FROM ANODE TO CATHODE
STEEL PIPE WHEN CONNECTED TO GALVANIZED PIPE AS SHOWN, BECOMES THE CATHODE AND MAY BE PROTECTED FROM CORROSION BY CURRENT FROM THE ANODE
AT POINT WHERE GALVANIZED PIPE IS ATTACHED TO STEEL PIPE, CURRENT FLOWS FROM CATHODE TO ANODE THROUGH PIPE—THIS IS COMPARABLE TO CURRENT FLOW IN EXTERNAL CIRCUIT OF DRY CELL FROM + TO − (SEE FIG. 4)



LEAD SHEATH ON CABLE IS ANODIC TO BOTH COPPER GROUND-WIRE AND COPPER RODS - CONNECTION BETWEEN LEAD SHEATH AND GROUND-WIRE IS PATH THROUGH WHICH CURRENT COMPLETES GALVANIC CIRCUIT AND IS COMPARABLE TO EXTERNAL CIRCUIT OF DRY CELL. (SEE FIG. 4)

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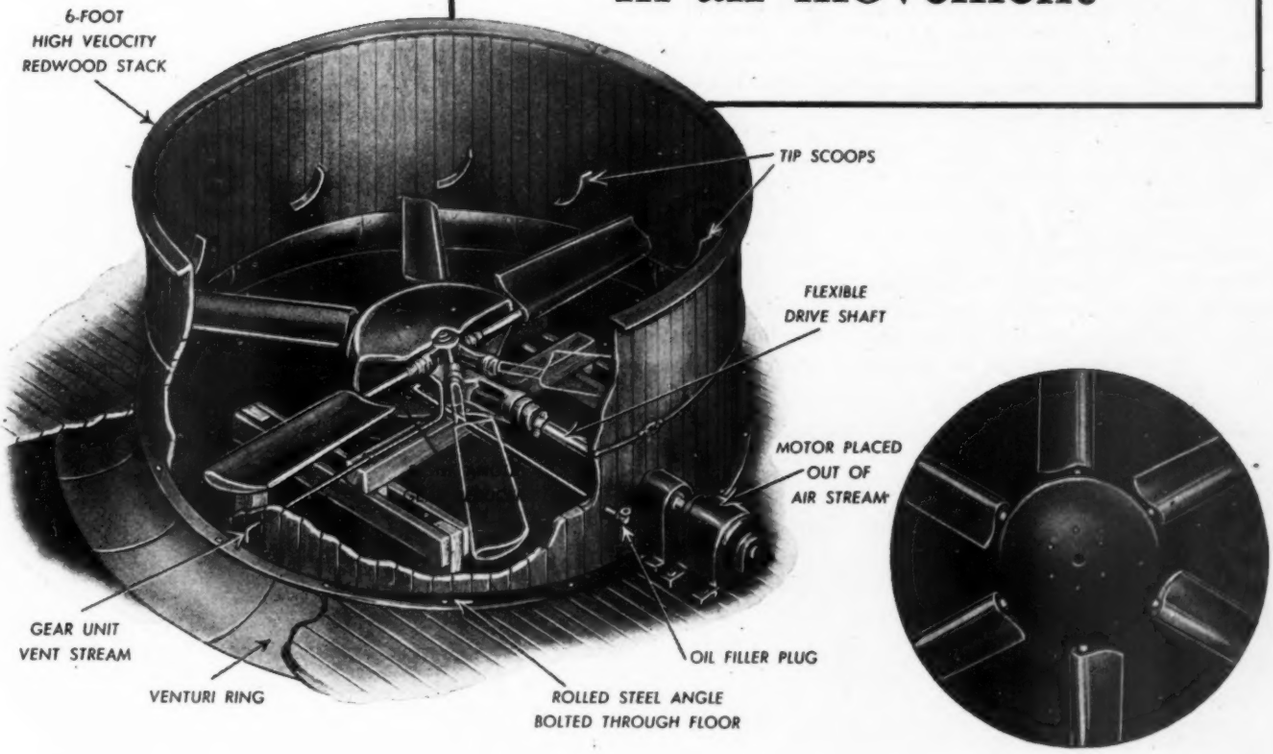

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current flow, is shown in Figs. 7, 8, 9, 10, 11, and 12.

In the manufacture of commercial metals, a number of different basic metals and materials are mixed and melted together to produce an alloy metal having the desired characteristics, such as strength and flexibility. Some of the particles of these different metals and materials may not mix thoroughly and may appear at the surface of the finished metal. When buried, these particles may act the same as dissimilar metals and corrosion takes place at those spots, with the galvanic current flowing into the soil to some other surface of the same metal and through the metal back to the corroding spot. Deep pitting and eventually holes through the metal may result.

The amount of electric current that flows and the rate of corrosion where two or more buried metals are connected together, depends to a large extent on the conditions of the soil; that is, the kind and amount of chemicals in the soil, whether it is dry or wet, the extent to which air reaches the surface of the metal, and whether the soil conditions are uniform along the surface.

In a damp corrosive soil, corrosion of a galvanized pipe connected to a copper pipe may be very rapid with failure of the galvanized pipe in a few years. If these same pipes were in dry sandy soil, no noticeable corrosion might occur in many years.

The size of the two pipes of different metals is an important factor also in the rate of corrosion. If the surface of galvanized pipe is large and the copper small in comparison, even in corrosive soils the corrosion may not be rapid. An example of this is the brass shutoff valve in a buried steel gas service pipe. This causes no appreciable corrosion of the steel pipe because of the relative size of the areas. If the area of the galvanized surface is small and that of the copper or steel is large, however, very rapid corrosion of the galvanized surface may result. A good example of this is the rapid corrosion of galvanized caps used on steel service stubs—a practice discontinued some time ago by many pipe line companies.

A considerable reduction in corrosion may be made by avoiding, as far as is practical, the use of dissimilar metals in corrosive soils, or by *not* connecting them together in such a way that electric current can easily flow from one to the other. If they must be connected together, it may be practical to do so with electrical insulating material that will keep electric current from flowing.

The condition of the soils that contact the buried metals has other important effects on corrosion. When a metal such as a pipe line extends through different kinds of soil, as sand and clay, or through soil that is dry in one area and wet in another, corrosion may result because of these soil variations even though the same kind of metal is used throughout. Usually in the soils that contain certain chemicals and where the soil is damp, corrosion will take place with electric current produced by the chemical action between the pipe and soil. The current will flow from the surface of the pipe where it is corroding through the soil to the surface of the pipe in the drier soil.

(To be continued)

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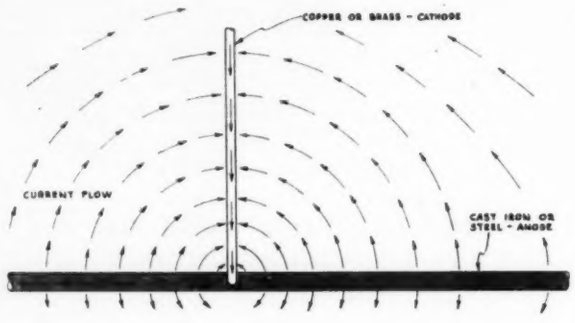
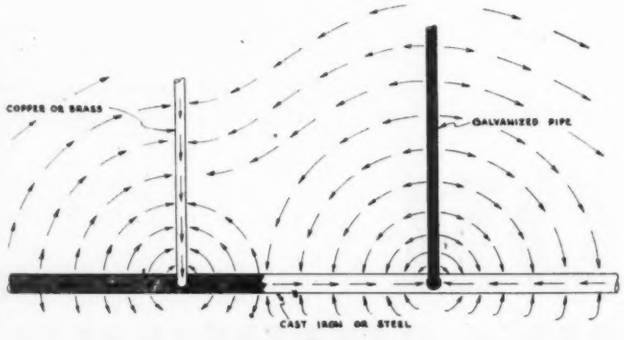
Fig. 10. Corrosion caused by dissimilar metals

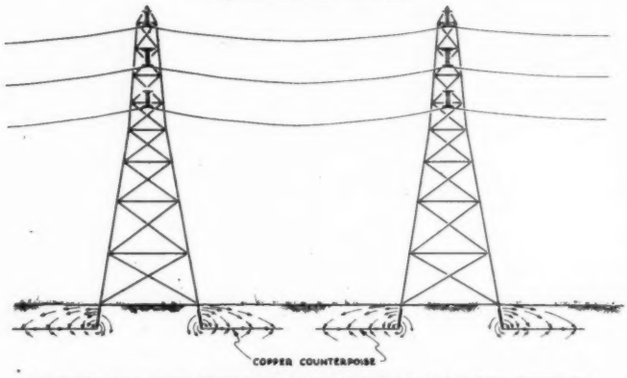


CAST IRON OR STEEL PIPE IS ANODIC WITH RESPECT TO COPPER OR BRASS PIPE - THE CURRENT FROM THIS ANODE PROBABLY PROTECTS THE COPPER OR BRASS FROM CORROSION



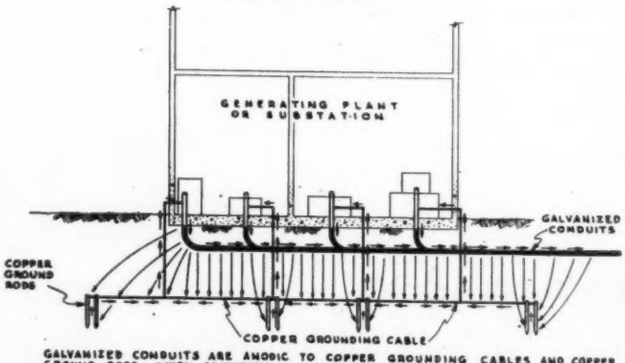
CAST IRON OR STEEL MAY BE ANODIC TO COPPER PIPE BUT CATHODIC TO GALVANIZED PIPE - GALVANIZED PIPE IS ANODIC TO *BOTH* CAST IRON OR STEEL AND COPPER OR BRASS

Fig. 11. Corrosion of galvanized tower footings caused by dissimilar metals



GALVANIZED STEEL TOWER FOOTINGS ARE ANODIC (BY ABOUT 1.0V.) TO COPPER COUNTERPOISE CABLE. AREA OF STEEL FOOTINGS ARE SMALL COMPARED TO COPPER CABLE HENCE RAPID CORROSION OF FOOTINGS IS POSSIBLE IN CORROSIVE SOILS.

Fig. 12. Corrosion of galvanized conduits caused by dissimilar metals



GALVANIZED CONDUITS ARE ANODIC TO COPPER GROUNDING CABLES AND COPPER GROUND RODS. WHEN CONNECTED TOGETHER CORROSION OF CONDUITS RESULTS WHERE SOILS ARE CORROSIVE.

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P 615.

Pipe Lines in Industry

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by M. E. Conkling

United Contracting Company

BUSINESS men prior to 1850 would not have referred to the transportation system of the country, or the world, as an industry. Today, there are as many industrial phases of transportation as there are types of conveyances and of items to be transported.

One of the greater mediums of moving gaseous and fluid commodities to and through channels of utility is the modern pipe line, although technically, modern is not the word for the system. Early stages of civilization are responsible for its birth, although twentieth century ingenuity and "know how" have nurtured it to the size of a commercial giant, a convenient and economical facility to normal activity, and an indispensable requisite in today's emergency.

The pipe line, as a method of conveying liquids, is not new. Aqueducts were constructed to bring water overland to ancient cities. Early, if not primitive, Asiatic builders joined together lengths of bamboo trunks to form a crude pipe to carry their water supply. There are traces of clay tubes used for drainage purposes in sections of the medieval world when man's reasoning was employed to supplement natural surroundings.

It took today's industrial interdependence to precipitate the establishment of "pipelining" as the essential means of petroleum and other liquid transportation. The steel and hard metal industry developed and improved cast-iron and steel pipe that was first proved in sewer and water systems throughout the world, giving the promise of further usefulness, if required by needs more pressing than those of a public that was still unaccustomed to the possibilities of this thing called science. With the bursting of the chrysalis, the still infant petroleum industry sprang to gigantic size and scope, at times pulling, and, in turn, being pushed by related commercial and scientific fields.

As a result, pipe lines came to be of paramount importance in the petroleum industry, more especially in the transporting of gas, gasoline, and crude oil. This system has the advantage of automatic operation, therefore slight overhead and upkeep cost. It simplifies operation problems with easy rights-of-way, one-way traffic, and permanent routes. It provides safety in the minimizing of human contact with the operating system, as most lines are underground.

With the cooperation of agglomerative industry, it can be no surprise that today pipelining is more than an auxiliary construction activity. The steel industry made available the materials for construction of a system of conveyance that is safe and efficient. Other phases of business contributed to development. Mechanical and engineering genius devised the manner of construction, built specialized machines and equipment to accomplish a definite job, discovered the revolutionizing processes of acetylene and electric arc welding. American business, as adventurous as the men behind it, met the investments and the risks, and those same have followed the path of what was an enterprise to what is now an industry.

The public in general has no concept of the magnitude of the pipe line systems. The wooden river barge hauling barrels of oil has been replaced by a steel pipe, lying on the bottom of the canal. A Kansas wheat field can show only the golden color of the grain, and not the black gold flowing through a 16-in. pipe 30 in. underground. With the exception of occasional pump stations, this great transportation system is completely hidden from the eye of the casual observer, one of the facts contributing to its safety.

There are more than 175,000 miles of pipe lines in 24 states of this country, and they were built at a cost of more than $1,500,000,000. Through these lines, since their construction, have flowed more than 5,000,000,000 bbl. of oil, and the rate of flow is increasing annually. More than 40,000 men, earning above $65,000,000 a year, are employed to manage and maintain the systems.

Thousands of miles of "big inch" pipe have been laid in the last two years. Thousands of miles more will be laid when material and labor conditions will permit.

From the standpoint of safety, economy, efficiency, and speed, pipe lines are indispensable as a method of transportation for liquids and gases. Today, as never before, they are carrying precious cargo that, to a great extent, will determine our speed of success in this, the greatest of all wars. —— ☆ ☆ ☆

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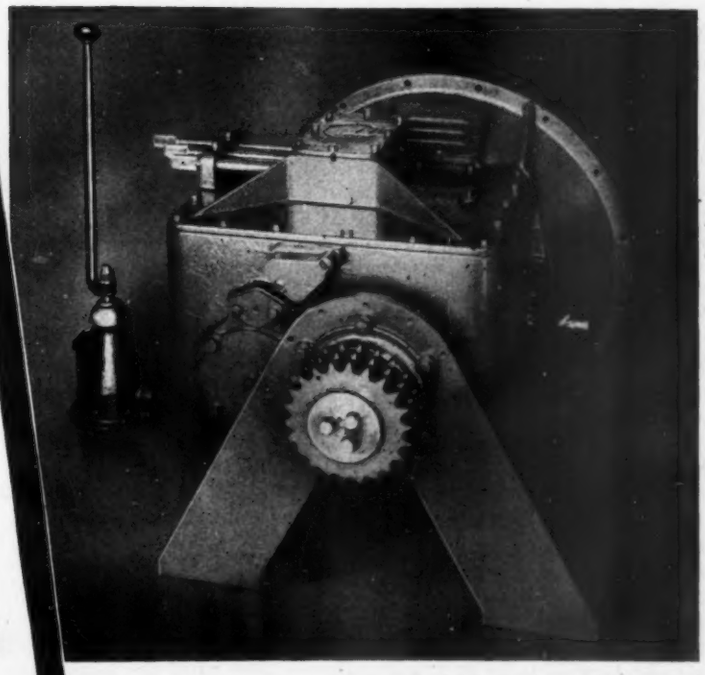

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P 615.635.4

Concepts and Methods of Cathodic Protection*

☆ Measurements of cathodic polarization and problems of interference on underground structures

PART 1

by J. M. Pearson
Susquehanna Pipe Line Company

Introduction

THE growing use of cathodic protection against corrosion of buried structures brings with it numerous problems of design of electrical measurements, and of coordination of the interests of parties other than those immediately concerned. There are also the inevitable confusions that arise from differing terminologies, and occasionally from differing concepts of the processes or mechanisms involved.

This paper is intended to set forth certain concepts and methods that have been useful in meeting these problems. The methods, which depend upon electrical measurements, are detailed and the reduction or avoidance of instrument errors is considered.

The basic concept most useful in understanding underground corrosion is that of its electrochemical nature. According to this viewpoint, corrosion occurs because there simultaneously exist anodes and cathodes at different places on the same body of metal. These places may be widely separated, as sometimes occurs on a buried pipe line. The anodes may be hundreds of feet from the cathodes as evidenced by the long-line currents linking the oxidation at the anodes with the reduction at the cathodes. More often, the anodes and cathodes are closely adjacent as evidenced by an anodic pit immediately surrounded by a cathodic area. In the extreme, as in the case of solution of the metal by acid, the anodes and cathodes are more nearly molecular in size, or are determined by the size of grains of crystal in the metal structure. In any case, the co-existence of the anodes and cathodes leads to losses of metal at the anodes, and in a few cases to solution of it by products of reduction at the cathodes

In the case of any metal whose surface is substantially all cathodic or all anodic, corrosion occurs at a minimum rate. Pure zinc tends to become anodic all over, and, lacking a cathode, its rate of corrosion is very low. Stainless steel alloy has a surface which in the presence of oxygen tends to become entirely cathodic. Under the right conditions the cathodic film tends to extend over and to plug incipient anodes, maintaining the surface stainless. In either of these examples conditions that establish cathodes or anodes, as the case may be, immediately result in vigorous corrosion.

In those cases where the surface of a corroding electrode is mostly cathodic, the rate of corrosion is controlled by the smallness of the anodes, and the process is said to be anodically controlled. The converse is true of surfaces predominately anodic. In the case of corrosion of ferrous materials, the rate of corrosion is more dependent upon environment than upon the metal itself. Of all elements in the environment, oxygen is the most important factor. In the presence of oxygen, a stable pattern of cooperating anodes and cathodes is set up. The well aerated areas become coated with a film upon which oxygen is reduced, whereas the metal at the less aerated areas begins to go into solution and to become anodic. The very presence of the ferrous ions near the anodes further reduces the oxygen tension at the metal surface, while the galvanic current from the anodes to the cathodes in the electrolyte helps to prevent the migration of ferrous ions through the cathode film. The anodes thus tend to grow until the local action current is sufficient to "cathodically protect" the adjacent cathodes, at which point a kind of equilibrium is established. Temporarily detached, the cathodes would lose their protection and begin to discharge ions through the pores in their films and to form anodes anew. Likewise, the anodes with the current through the metal from the cathodes shut off would go into solution much more slowly and inward diffusing oxygen would again reach the surface of the metal to form cathode areas.

In the complete absence of oxygen, ferrous ions can form at the expense of hydrogen ions, the resulting corrosion being at a negligibly low rate except in acid solutions or at elevated temperatures. In the presence of organic material of suitable type, and when the oxygen tension has fallen very low the growth of sulphate reducing bacteria produces a stable environment that leads to a high rate of corrosion.

Electrode potential is usually conceived as potential difference between the electrode and surrounding electrolyte, whereas any experimental approach to its measurement necessarily involves more than one electrode. The second, or reference, electrode is selected because of its reproducibility and because it will supposedly carry enough current to operate the observing instruments without serious polarization. As some conventional value can be ascribed to the reproducible reference electrode it is possible to subtract that value from the observed potential difference and think of the remainder as the measured "electrode potential." The measurement of the potential of a non-corroding electrode against a reference electrode is most easily accomplished in the laboratory by the use of a null instrument whose indicator is so sensitive that the current drawn does not alter the potential of either electrode.

The electrode potential of a corroding metal is not so easily measured. The local cell action of the corroding metal produces electrical gradients in the electrolyte, which leads to various results depending upon where the reference cell is located. As this location is made remote enough, however, locations can be found

*This paper, copyrighted by Susquehanna Pipe Line Company under the title "Measurements of Cathodic Polarization and of Problems of Interference on Underground Structures," was presented before the National Bureau of Standards Corrosion Conference, 1943.

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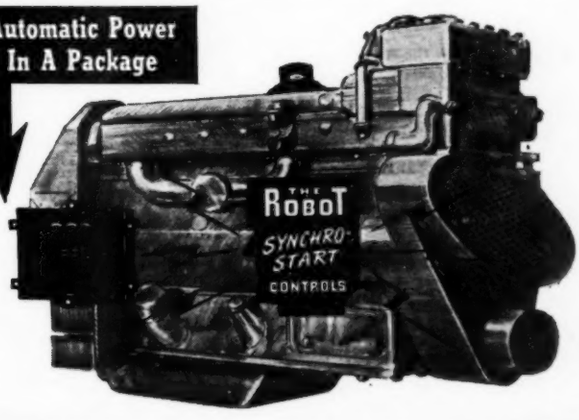

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for which determinations are in agreement. As the local action currents begin and end upon the corroding electrode, the distance to which it is necessary to move the reference electrode depends upon the space occupied by the galvanic currents, and is of the order of the separation of the anode and cathode areas.

In the field, the measurement of electrode potentials of corroding buried metal is further complicated by electrical gradients in the earth, which may or may not be related to the electrode. Sometimes the part of the structure under study is predominately anode or cathode, and the galvanic current flowing between it and the earth is so extensive that it is easier to account for it by measurement than by moving the reference electrode out of its path.

Polarization

When one has taken the precaution to select a reasonably non-polarizable reproducible reference half-cell, and has accounted for the effects of potential gradients that may affect the observations, and has accepted some conventional value for the half-cell potential, he may make a valid observation and determine the potential of a corroding electrode. If now he passes a current between the electrode and the electrolyte he can, by taking the same precautions to account for gradients, observe any change in potential of the electrode caused by the current flow. It is this change in potential that is conventionally termed polarization. As only changes in potential are significant, it is clear that the conventional value of the reference half-cell is immaterial so long as it possesses the qualities of constancy and reproducibility. It is usually convenient to plot polarization curves showing the total observed P.D., simply specifying the particular reference cell used.

Because of this habit, confusion sometimes arises in regard to the polarization of buried structures. Seasonal changes sometimes result in a change of electrode potential, which is confused, in the absence of a new polarization curve, with a change in the polarization of the structure. In most cases both electrode potential and polarization may be expected to change, but the relative importance of the changes must be determined by measurement.

The observed polarization can be accounted for by one or more of several mechanisms. If the corrections made take care of the IR drop in the electrolyte up to the electrode surface, but do not account for IR drops at the surface or in a possible surface film, the observed polarization can be the result of a combination of changes of e.m.f. and of IR drop at or near the metal surface. The changes in e.m.f. are due to reduction (or oxidation, depending on current flow direction) effects of the impressed current. The changes in IR drop may be due to at least two presently recognized phenomena. For buried structures, the most important one is the IR drop in the surface film. On a bare pipe line this film may have a resistance of 200 ohms for one cm^2 in well aerated areas, and only 20 ohms in areas that are poorly aerated. Also, a high resistance protective coating produces an even more pronounced IR drop at the pipe surface. For an electrode of stainless steel, this film resistance is about 30,000 ohms for one cm^2, and is by far the dominating factor in potential changes at the surface. The other factor in producing IR drops at the electrode surface is chemical polarization, which occurs in the electrolyte very close to the electrode surface. Chemical polarization occurs under conditions in which the polarizing current and the electrode reactions remove the ions that conduct the current, from the electrolyte in the immediate vicinity of the electrode. This increases the IR drop near the surface, but also introduces a concentration-cell potential. Neither of these is of great significance to the cathodic polarization of buried structures.

One of the chemical changes that is of major importance is the production of alkali and the increase of the pH at the cathodically polarized surface. In the case of steel, this effect modifies the effects of changes of oxygen concentration, producing conditions that are more favorable to the maintenance of cathodic protection. In the case of amphoteric metals, care must be exercised that the environment does not become so alkaline as to dissolve the metal.

It is clear that any measurement of the polarization of a buried structure must be made to differentiate between the effects of purely IR drop and the electrochemical results of the current flow. Only the latter is of any use in controlling the rate of corrosion.

Just how cathodic polarization affects the corrosion rate can be understood in light of the concept of the superposition of electric currents. This idea can be simply stated: In any conducting network, containing any distribution of e.m.f.'s and conducting paths, the current that flows as the result of any one e.m.f. follows the same paths in the same way and has the same value as though all the other e.m.f.'s were absent. It follows that the total current observed in any branch of the

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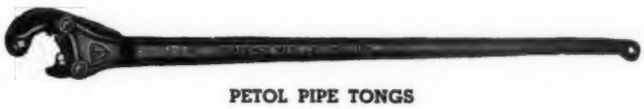

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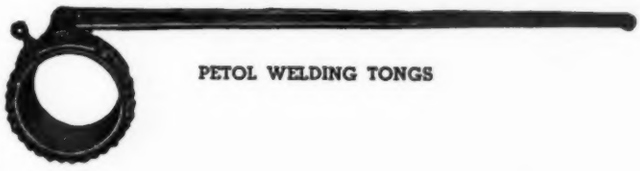

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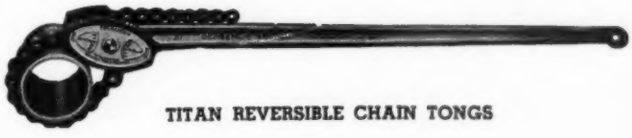

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network is the algebraic sum of all the components individually conceived as resulting from the individual e.m.f.'s. (The validity of this concept is assumed here to be well established. See "Electricity and Magnetism," by J. H. Jeans, p. 90.) The anodes and cathodes on a corroding electrode each possesses an e.m.f. The total effect of all of them is a net flow of current into the electrolyte from the anodes, and an equal net flow of current from the electrolyte into the cathodes. If now we connect the electrode to a source of current to polarize it cathodically, the same concept of super-position explains what happens. The current resulting from the polarizing circuit flows into the electrode exactly as it would if there were no e.m.f.'s at its surface at all. In other words, if a fraction x of the polarizing current reaches the anode areas, then the fraction 1-x must reach the cathode areas, and the value of x is in no way dependent on the e.m.f.'s existing at the electrode surface. The value of x depends solely on the resistances near the anodes and cathodes. Thus for corroding steel the resistance per unit area of the cathodes can be as much as ten times the resistance per unit area of the anodes, with the result that the polarizing current flows proportionally more to the anodes.

Whatever the fraction x is of the polarizing current that flows into the anodes, so long as the resistances are fixed, x will not vary. However, the variation of the e.m.f.'s as the result of polarization can produce a variation of the independent currents that result from them. This has been many times observed when, for example, a cathodic protection installation is shut down and "long line" currents flow due to the persistence of the polarization.

If now we focus our attention upon the anodes of the corroding electrode we find superposed upon the local action current leaving the metal, the fraction x of the polarizing current entering the metal. Whatever its value is, this fraction represents an actual reduction in the net current leaving the anodes. It consequently follows that as the total polarizing current is made large enough the fixed fraction that flows to the anode will eventually cancel the anode discharge and stop the anode reaction.

This condition for the completeness of cathodic protection is identical with the conditions determined by experiments such as those of Mears and Brown.[1]

[1]R. H. Brown and R. B. Mears, The Electrochemical Society Preprint 81-19.

It is interesting to observe, in the case of a corroding electrode, that there is little change in the e.m.f.'s of the local action circuit until there is a reversal of current at the anodes. This reversal, in the case of steel for example, results in the discharge of hydrogen rather than in the plating out of ferrous ions. There consequently is a discontinuity in the potential-log current relation marking the onset of the hydrogen overvoltage. This point is of value in determining the initial current needed to give cathodic protection.

The long-time effects of cathodic polarization are interesting and merit more quantitative observation than they have received. For example, the formation of alkali in a well aerated area results in a gradual sealing of the anode areas by the production of a cathodic film by infusing oxygen. The structure may become more noble in its potential, even though it may still be polarized enough to suffer no corrosion. Whether it is so polarized can only be determined by measurement of the "E- Log I" relation.

Editor's Note: This article will be continued in an early issue of *The Petroleum Engineer.*

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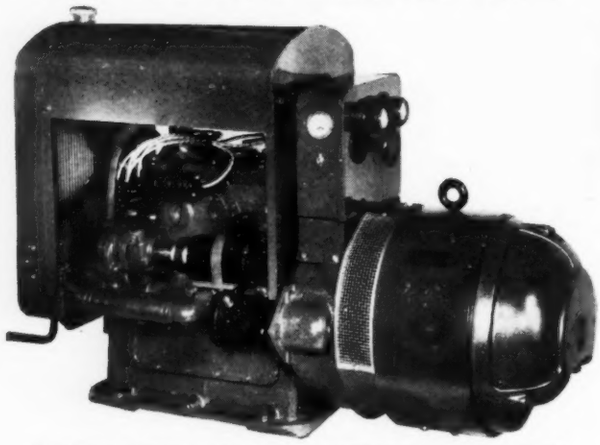

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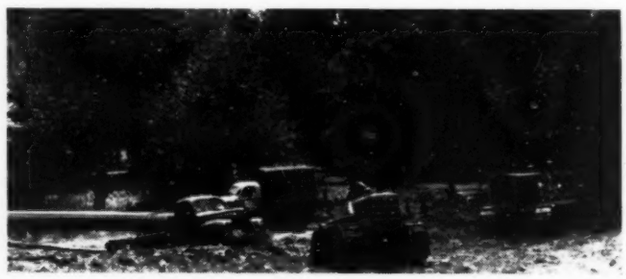

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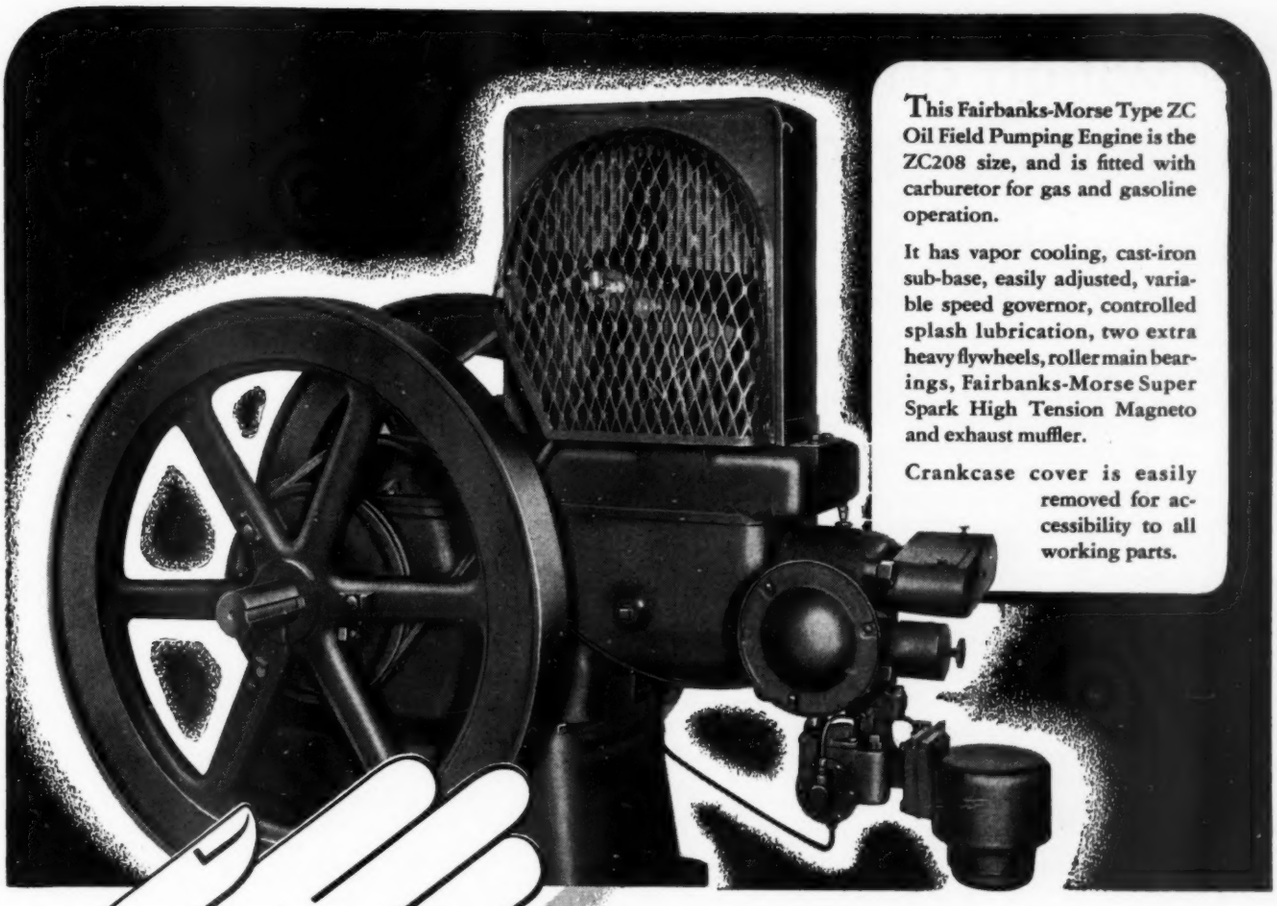

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Derivation and Application of Material-Balance Equations to Magnolia Field

by Alton B. Cook

Assistant Petroleum Engineer, U. S. Bureau of Mines, Bartlesville, Oklahoma

Calculation of future reservoir pressures. Material-balance equations can be used to predict future reservoir pressures corresponding to various future rates of production of oil, gas, and water and to calculate future pressures when gas, water, or both are returned to the reservoir. These calculations require knowledge of the original volume of oil and gas in the reservoir, initial and subsequent reservoir pressures, reservoir temperature, quantities of oil, gas, and water produced, and estimates of future productions, shrinkage of the reservoir oil and volume of gas liberated upon reduction of pressure, the compressibility of the free gas in the reservoir, and the rate of water encroachment into the reservoir.

The method of "trial and error" is used to calculate future reservoir pressures when the material-balance equations are used. The calculations are relatively simple for gas-expansion reservoirs, because W_e in such reservoirs equals zero. In making the calculations a likely pressure for P_2 first is assumed, and values corresponding to this pressure are substituted in equation (d) or (e). Values representing the volumes of oil and gas produced plus the assumed future production of oil and gas to the projected date are substituted for n_b and g_b in either of the two equations. If the calculated values on each side of the equation balance, the assumed pressure is correct; otherwise, another pressure must be assumed and the equation solved again.

The calculations are much more complex for reservoirs into which edgewaters encroach. When calculating future pressures in water-drive reservoirs a relationship between the rate of water encroachment and pressure decline must be established. The assumption that this relationship is linear may be sufficiently accurate to permit prediction of future reservoir pressures for some fields. According to Schilthuis,[51] "In many cases, it may be assumed that the rate at which water enters a field is proportional to the pressure gradient that exists between the water-bearing strata and the oil- and gas-reservoir. For practical purposes, the value of this gradient would be the difference between the value of the original reservoir pressure and any subsequent value, or $(P_1—P_2)$."

Based upon the above assumption, the rate of water encroachment into a reservoir can be estimated if the total volume of water that has encroached into the reservoir has been calculated by equation (f) and a reservoir-pressure decline curve, such as shown in Fig. 22, is constructed to show the decline in pressure that has occurred in the reservoir since discovery. If the area under such a curve, expressed in lb. per sq. in.-days is represented by A, and the rate of water encroachment in cu. ft. per lb. per sq. in. drop in reservoir pressure per day is represented by c, then $cA=W$ or $c=\frac{W}{A}$.

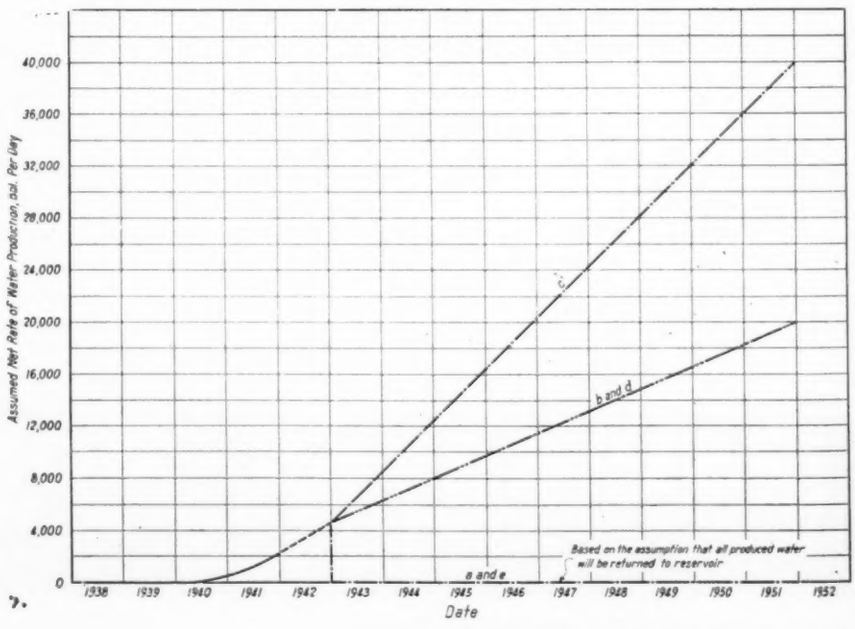
Because $W=W_e+w$ and $cA=W$, $W_e=cA—w$, equation (f) then can be rewritten:

$$cA—w=\frac{g_b}{f_2}—\frac{S_2—S_s}{f_2}n_b+n_bF_2—G_1\times\left(\frac{f_1}{f_2}—1\right)—N_1\left(\frac{F_2}{F_1}+\frac{S_1—S_2}{F_1f_2}—1\right) \quad \text{. . . . . (i)}$$

If the daily rates of production of oil, gas, and water from a reservoir for a future period, are estimated, and a pressure-decline curve is extended accurately to the date representing the end of that period, the numerical value of (cA—w) should be equal to the righthand side of equation (i). When calculating the reservoir pressure that will exist at a date several years in the future, it usually is advisable to calculate the pressures at the end of one or more future periods preceding that date; if, for example, it is desired to extend the pressure-decline curve five years into the future, calculated pressures at the end of 1, 3, and 5 years should supply enough data to extend the curve accurately.

Sample calculation. The data available on the Magnolia field were insufficient to establish a relationship between the rate of water encroachment and the difference existing between the initial and subsequent reservoir pressures. For the purpose of demonstrating the method of calculating future reservoir pressures, the rate of water encroachment into the Magnolia reservoir is assumed to be directly proportional to the decline

Fig. 21. Assumed net rate of water production, Magnolia field, Arkansas



[51] "Active Oil and Reservoir Energy," Ralph J. Schilthuis, *A.I.M.E. Petroleum Development and Technology*, 1936, p. 39.

Baash-Ross News

BAASH-ROSS TOOL COMPANY · LOS ANGELES · HOUSTON · NEW YORK

PETROLEUM ENGINEER EDITION

FOUR things make th one of the riskiest of all rig operations!

When you use drill pipe slips to support a drill collar in the table, you are practically asking for a costly fishing job. Why? Because, compared with ordinary drill pipe, there are *four* factors that add extra risk to handling drill collars . . .

1. HARD SURFACE. The ends of drill collars are heat-treated in the area where the slips take hold. The resulting hard surface makes it far more difficult for slips to get an adequate grip on the collar!

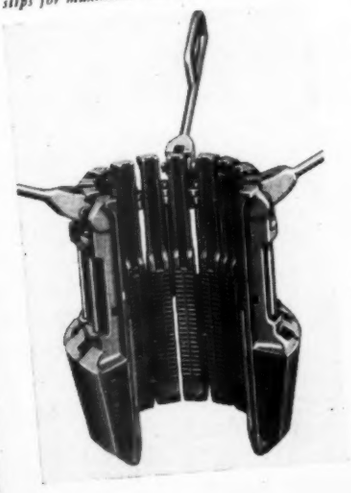
2. NO SHOULDERS. The majority of modern drill collars are made flush top to bottom. This means there are no shoulders to stop the collar from slipping once it has started!

3. VARIABLE DIAMETER. Drill collars, rotating against the abrasive, fresh-cut walls of the hole, rapidly lose diameter. Ordinary fixed curvature slips cannot compensate for this wear, become less and less efficient as collar is used.

4. INSUFFICIENT WEIGHT. All slips depend upon wedging action for grip pressure. When supporting drill collars, usually only the weight of the bottom of the string is available to wedge the slips. This means less effective grip, greater risk of slipping!

BAASH-ROSS DRILL COLLAR SLIPS

ABOVE *"Regular" Type showing how multiple narrow slip segments are flexibly hinged together.* **BELOW** *"Long" Type showing how segments extend above slip area to provide seat for a Baash-Ross Safety Clamp (see page 265 of your 1944 Composite Catalog). Both types have renewable slips for maximum economy.*



Here's the solution . . .

BAASH-ROSS DRILL COLLAR SLIPS!

These slips are specifically engineered to eliminate one of the riskiest of all rig operations . . . supporting a drill collar through the table with "fixed diameter" slips.

They differ from ordinary slips in that they are made up of many narrow segments flexibly hinged together to insure an adequate, full-diameter grip on the collar at all times and under all conditions. They w-r-a-p around the collar like a chain tong, fitting every inch of the circumference whether the collar is new, old, round or out-of-round!

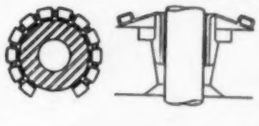
Compare this full-circumferential grip with the partial grip provided by ordinary "fixed-diameter" slips . . . that is, slips designed to fit a certain diameter pipe and that diameter only. Trouble is, drill collars don't have a "fixed" diameter. Their constant rotation against the abrasive, fresh-cut walls of the hole causes them to wear rapidly. And they not only become smaller in diameter, but often out-of-round as well. Ordinary rigid type slips cannot compensate for this wear (see illustration) . . . consequently grip the collar less and less securely. This reduced gripping area—combined with a hardened surface, insufficient weight and flush construction—make the use of rigid type slips to hold drill collars an invitation for a costly fishing job!

But the Baash-Ross Drill Collar Slips practically eliminate these risks by the full-area grip they take on any drill collar, regardless of its shape or diameter. They are one of the best safeguards you can put on your rig!

TWO TYPES—WIDE RANGE OF SIZES. Baash-Ross Drill Collar Slips are available in two types—"Regular" and "Long." The "Long" type has extensions above the slip surface providing a seat for a Baash-Ross Safety Clamp for double protection. Both types have interchangeable liners for long life, low maintenance. Both are available in sizes to fit all diameters of drill collars, each size handling a variation of 1½" in diameter.

Get the full story on this important safeguard from your Baash-Ross dealer, or write direct for bulletin!

BAASH-ROSS DRILL COLLAR SLIPS



When the drill collar is new, the flexible slips rest high in the tapered bowl, giving a full grip. As the drill collar wears, the slips rest lower in the bowl . . . but always give the same full grip.

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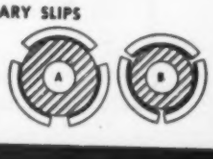
. . . give adequate grip with new drill collars (A) . . . but give less and less grip as drill collar wears (B)!



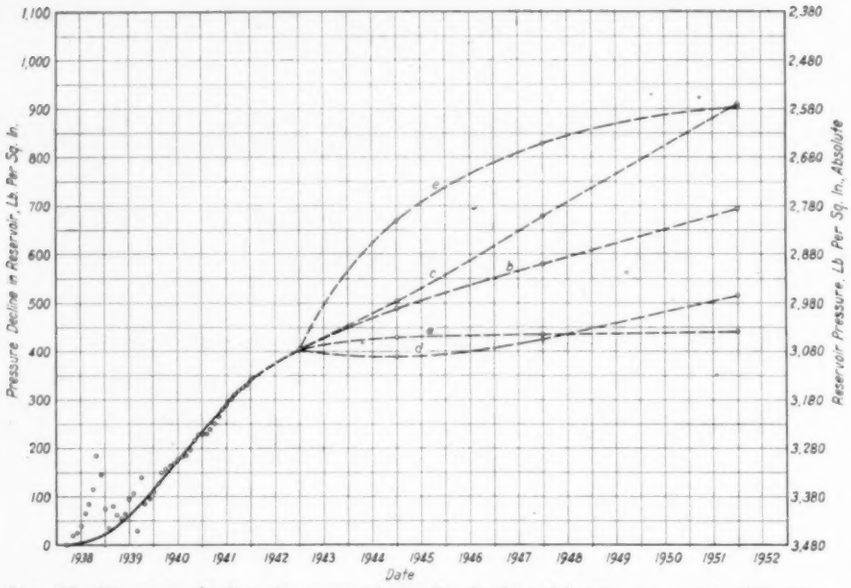


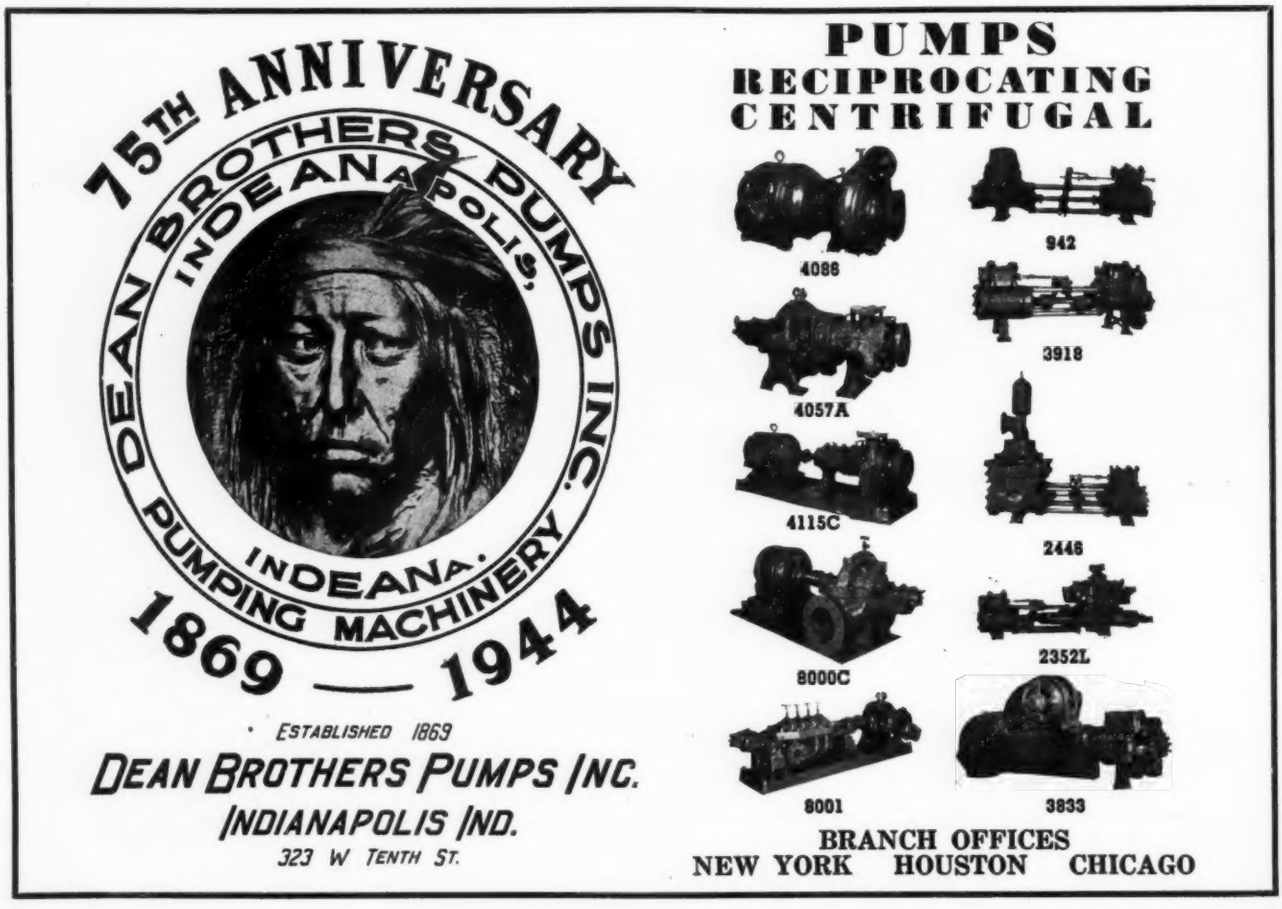
Fig. 22. Pressure decline in reservoir and calculated future reservoir pressures, Magnolia field, Arkansas

in reservoir pressure. In the following sample calculations to determine the reservoir pressure as of January 1, 1943, the production data given in Table 16 are used. The assumption is made that the daily rate of oil and gas production for January, 1942 (18,800 bbl. of oil and 15,023,000 cu. ft. of gas) will continue throughout 1942 and that the average rate of water production for 1942 will be 3400 bbl. per day, as indicated in Fig. 21.

Cumulative productions to January 1, 1942, were 103.0×10^6 ($18,348,613\times5.6146$) cu. ft. of oil, $16,197\times10^6$ cu. ft. of gas, and 3.1×10^6 ($547,695\times5.6146$) cu. ft. of water. The assumed productions for 1942 are 38.5×10^6 ($18,800\times365\times5.6146$) cu. ft. of oil, 5483×10^6 ($15,023,000\times365$) cu. ft. of gas, and 7.0×10^6 ($3400\times365\times5.6146$) cu. ft. of water. The estimated cumulative productions to January 1, 1943, therefore, are 141.5×10^6 ($103.0\times10^6+38.5\times10^6$) cu. ft. of oil, $21,680\times10^6$ ($16,197\times10^6+5483\times10^6$) cu. ft. of gas, and 10.1×10^6 ($3.1\times10^6+7.0\times10.^6$) cu. ft. of water.

The area, corresponding to A in equation (i) under the pressure-decline curve (see Fig. 22) from its origin to January 1, 1942, is 21.35 square units or 194,800 lb. per sq. in.-days. One square unit=9125 lb. per sq. in.-days, or 50 lb. per sq. in. multiplied by 182.5 days. As the calculated total volume of encroached water in the Magnolia field to January 1, 1942, was 68.5×10^6 cu. ft., and because $cA=W$, then $c=\frac{68.5\times10^6}{194,800}$ or 352 cu. ft. of water will encroach into the reservoir per sq. in. decline in reservoir pressure per day.

The extrapolated total decline in reservoir pressure (Fig. 22) to January 1, 1943, and the corresponding reservoir pressure on that date are 405 and 3075 lb. per sq. in., abs., respectively. The



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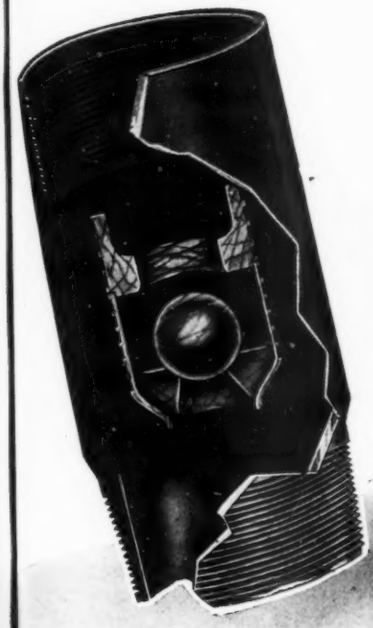

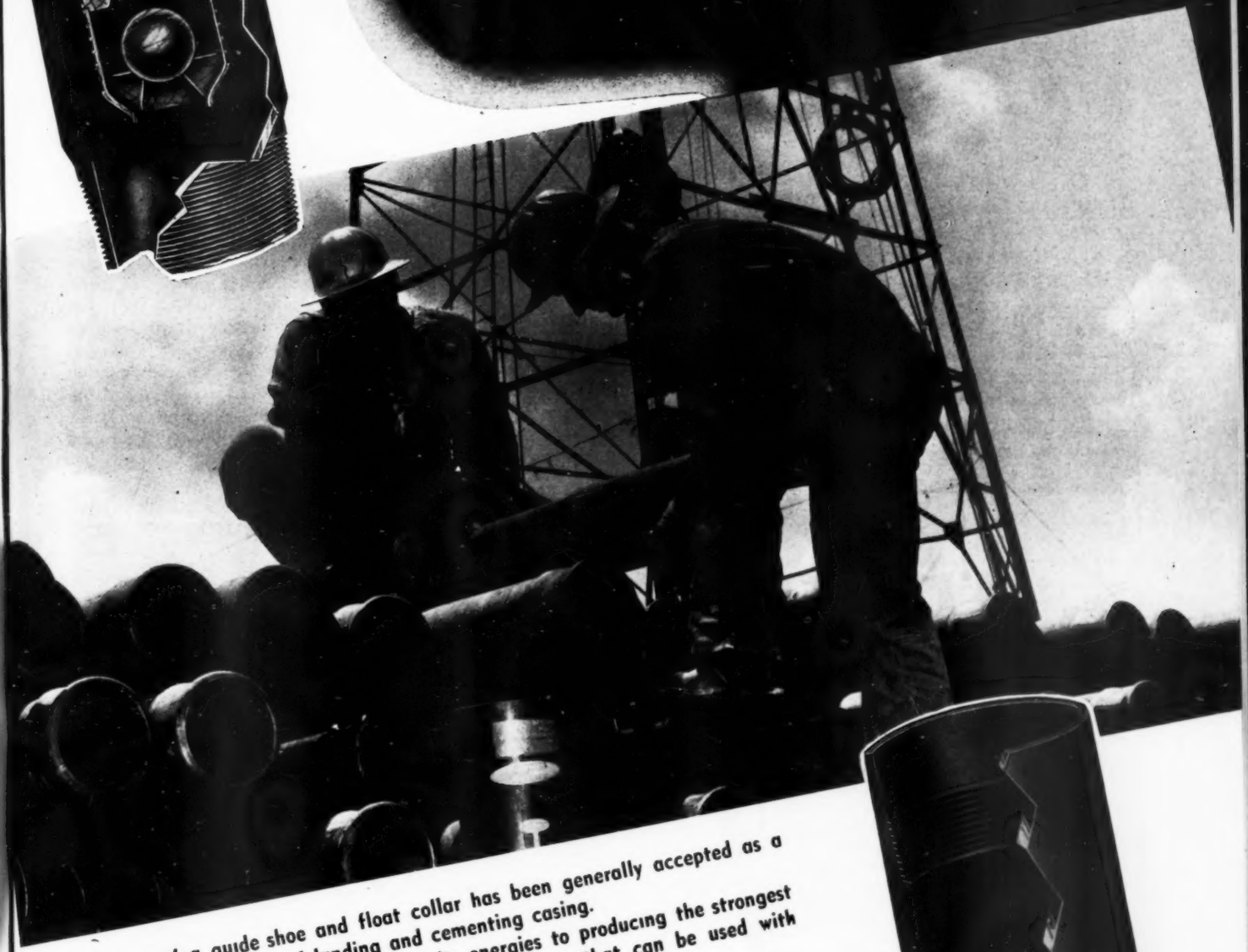

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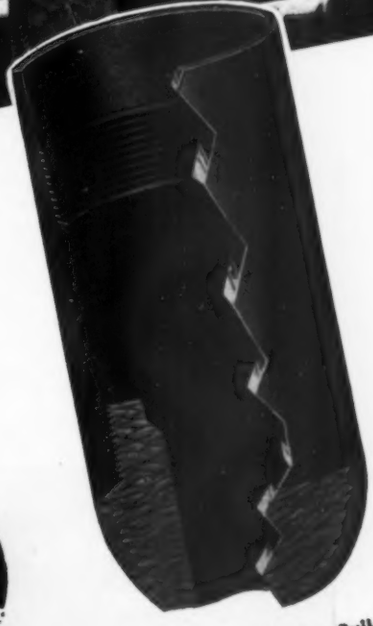

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total area (A) under the pressure-decline curve to January 1, 1943, is 36.35 square units or 331,700 (9125×36.35) lb. per sq. in.-days.

The following numerical values correspond to the reservoir pressure of 3075 lb. per sq. in., abs., as of January 1, 1943:

$c=352$; $A=331{,}700$; $w=10.1\times10^6$; $g_b=21{,}680\times10^6$;

$$f_2=\frac{3075\times520}{14.4\times667\times.901}=184.9;$$

$S_2=136.0$; $S_a=1.4$; $n_b=141.5\times10^6$; $F_2=1.435$; $G_1=433.7\times10^6$; $f_1=203.5$; $N_1=2026\times10^6$; $S_1=152.7$; $F_1=1.476$.

Substituting these values for the symbols in equation (i) gives:

$$352\times331{,}700-10.1\times10^6=\frac{21{,}680\times10^6}{184.9}-\frac{136.0-1.4}{184.9}\times141.5\times10^6+141.5\times10^6\times1.435-433.7\times10^6\times\left(\frac{203.5}{184.9}-1\right)-2026\times10^6\times\left(\frac{1.435}{1.476}+\frac{152.7-136.0}{1.476\times184.9}-1\right)$$

or $105.8\times10^6=106.0\times10^6$.

The close agreement between the values on both sides of the equality sign of the equation indicates that the extrapolated reservoir pressure as of January 1, 1943 (3075 lb. per sq. in., abs.), is approximately correct for the assumed conditions. If the equation had not balanced approximately it would have been necessary to assume another reservoir pressure as of January 1, 1943, and repeat the calculations.

The effect on the reservoir pressure of different rates of fluid withdrawal, or the net effect of different rates of fluid withdrawal when partial restoration of reservoir pressure is effected by the injection of gas or water, can be calculated in a similar manner. The calculated future reservoir pressures based upon five assumed rates of fluid withdrawal are given in Table 20 and shown graphically in Fig. 22. Curve a (Fig. 22) represents the results of calculations based upon an assumed daily rate of withdrawal after January 1, 1943, of 18,800 bbl. of oil and 15,023,000 cu. ft. of gas, and the return to the reservoir of all the water produced after January 1, 1943. Curves b and c represent the results of calculations based upon the same assumed daily rates of oil and gas withdrawal after January 1, 1943, and the corresponding daily rates of water production indicated by the rate-of-water-production curves shown on Fig. 21. Curve d (Fig. 22) represents calculations based upon an assumed daily rate of withdrawal after January 1, 1943, of 18,800 bbl. of oil, 3,756,000 cu. ft. of gas (net), and the corresponding daily rates of water production indicated by curve d (Fig. 21). In calculating curve d (Fig. 22) it was assumed that 75 percent of the 15,023,000 cu. ft. of gas produced daily—the assumption used to derive curves a, b, and c (Fig. 22)—was returned to the Magnolia reservoir. Curve e (Fig. 22) represents the results of calculations based upon assumed daily withdrawals after January 1, 1943, of 37,600 bbl. of oil and 30,046,000 cu. ft. of gas, and the return to the reservoir of all water produced.

The sample calculations are based upon the assumption that the rate of water encroachment was proportional to the difference between the initial and subsequent reservoir pressures. The production data on a number of fields should be studied to establish the validity of this assumption. If the assumption does not hold, perhaps an empirical equation can be derived; and equation (i) still can be used to estimate future reservoir pressures. For example: If the rate of water encroachment was found to be proportional to (P_1-P_2) multi-

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plied by a known function of the total volume of encroached water W, then, instead of plotting (P_1—P_2) against time as was done in constructing Fig. 22, (P_1—P_2) multiplied by the function of W should be plotted against time, and the values of A and c found as before.

Alternate method of calculating volumes of oil, gas, and encroached water in a petroleum reservoir. If two unknown factors are substituted in two independent equations the unknowns can be determined by solving the equations simultaneously. Therefore, if equation (i) contains only two unknowns they may be evaluated by setting up two equations, using equation (i) to represent conditions in the reservoir on two different dates. Equation (i) is:

$$cA - w = \frac{g_b}{f_2} - \frac{S_2 - S_s}{f_2} \times n_b + n_b F_2 - G_1 \times \left(\frac{f_1}{f_2} - 1\right) - N_1 \left(\frac{F_2}{F_1} + \frac{S_1 - S_2}{F_1 f_2} - 1\right).$$

If, for two specific dates the values of A in equation (i) are determined from a pressure-decline curve; g_b, n_b, and w from production data for the field; S_1, S_2, S_s, F_1, and F_2 from laboratory data on a subsurface oil sample; and f_1 and f_2 from compressibility data for the gas-cap gas, the values of c, G_1, and N_1 are the only unknown factors in the equations. If one of them is equal to zero (c would equal zero if no water moved into the reservoir, G_1 would equal zero if no free gas was in the reservoir initially, and N_1 would equal zero in a gas reservoir) or can be determined from some other source, the other two unknowns can be evaluated if they are set up in two separate equations and the equations are solved simultaneously.

Although unknown values of G_1 and N_1 can be determined mathematically by this method, it is not advisable to do so because the relative expansibility of G_1 is approximately of the same order as the relative expansibility of N_1. This results in determining large values of N_1 and G_1 by small differences. Furthermore, whenever the expansibility of the gas-cap gas (expressed in percent) for two pressure reductions is obtained by multiplying the expansibility of the reservoir oil (expressed in percent) by a constant, equations containing these values cannot be solved simultaneously. For example: Assume that the expansibility of the gas-cap gas resulting from a reduction in pressure from P_1 to P_2 is 3 per cent and from P_1 to P_3 9 per cent, and the expansibility of the reservoir oil from P_1 to P_2 is 1 per cent and from P_1 to P_3 3 per cent, the expansibility of the gas for each pressure reduction is three times as great as the expansibility of the oil. Simultaneous equations set up using expansibilities of the same relative order for N_1 and G_1 cannot be solved because that would be analogous to a simultaneous solution of x and y in the equations: (1), $x+y=3$ and (2), $2x+2y=6$. Therefore, application of this method in reservoir calculations is recommended only when the following conditions can be satisfied: (1) The volume of encroached water is one of the unknowns; (2) the rate of water encroachment is proportional to the pressure decline in the reservoir and a reliable pressure-decline curve can be constructed, or, if the rate of water encroachment is found from some empirical formula and a curve representing the rate of water encroachment can be constructed (see last paragraph of Sample Calculations under Calculations of Future Reservoir Pressures); and (3) the reservoir pressure has been reduced by more than 25 per cent of the initial pressure.

Sample calculation. To calculate the volume of water that had encroached into the Magnolia reservoir to January 1, 1942, and the initial volume of oil in the reservoir, the field and laboratory data given in Part I of this report (except those used to determine the initial volume of oil) and the pressure-decline curve shown in Fig. 22 are used.

Equation (i) then is set up to correspond with the field and laboratory data to and including July 1, 1940, and again to correspond with the field and laboratory data to and including January 1, 1942. For the first equation the area A under the pressure-decline curve (Fig. 22), to July 1, 1940, is 5.81 square units or 53,000 (9125×5.81) lb. per sq. in.-days; for the second equation the area under the pressure-decline curve to January 1, 1942, is 21.35 square units or 194,000 (9125×21.35) lb. per sq. in.-days.

In the two equations to be set up, c and N_1 are the two unknowns. G_1 was

TABLE 20

Calculated volumes of water encroachment and reservoir pressures at future dates for five different assumed production rates

Period	Assumed average daily production rates for indicated period				Assumed cumulative net production to end of period				
					Oil		Gas	Water	
	Letters correspond to curves in Figs. 21-22	Oil, bbl.	Net gas, M. cu. ft.	Net water, bbl.	Million cu. ft.	Million bbl.	Million cu. ft.	Million cu. ft.	Million bbl.
1	2	3	4	5	6	7	8	9	10
3-5-38 to 1-1-42	Actual	Actual	Actual	Actual	103.0	18.35	16,197	3.1	0.547
1-1-42 to 1-1-43	Estimated	18,800	15,023	3,400	141.5	25.21	21,680	10.1	1.8
1-1-43 to 1-1-45	a	18,800	15,023	0	218.5	38.92	32,646	10.1	1.8
1-1-43 to 1-1-45	b	18,800	15,023	6,270	218.5	38.92	32,646	35.8	6.4
1-1-43 to 1-1-45	c	18,800	15,023	8,490	218.5	38.92	32,646	44.9	8.0
1-1-43 to 1-1-45	d	18,800	3,756	6,270	218.5	38.92	24,422	35.8	6.4
1-1-43 to 1-1-45	e	37,600	30,046	0	295.6	52.64	43,612	10.1	1.8
1-1-45 to 1-1-48	a	18,800	15,023	0	334.1	59.51	49,095	10.1	1.8
1-1-45 to 1-1-48	b	18,800	15,023	10,500	334.1	59.51	49,095	100.5	17.9
1-1-45 to 1-1-48	c	18,800	15,023	18,170	334.1	59.51	49,095	156.6	27.9
1-1-45 to 1-1-48	d	18,800	3,756	10,500	334.1	59.51	28,535	100.5	17.9
1-1-45 to 1-1-48	e	37,600	30,046	0	526.8	93.84	76,510	10.1	1.8
1-1-48 to 1-1-52	a	18,800	15,023	0	488.2	86.96	71,027	10.1	1.8
1-1-48 to 1-1-52	b	18,800	15,023	16,500	488.2	86.96	71,027	235.8	42.0
1-1-48 to 1-1-52	c	18,800	15,023	32,125	488.2	86.96	71,027	419.9	74.8
1-1-48 to 1-1-52	d	18,800	3,756	16,500	488.2	86.96	34,019	235.8	42.0
1-1-48 to 1-1-52	e	37,600	30,046	0	835.1	148.75	120,374	10.1	1.8

Period	Area under pressure-decline curve to end of period		Calculated cumulative volume of encroached water at end of period				Calculated decline in reservoir pressure at end of period, lb. per sq. in.	Calculated reservoir pressure at end of period, lb. per sq. in., abs.
			Total (W)		Net (W_e)			
	Sq. units	Lb. per sq. in.—days	Million cu. ft.	Million bbl.	Million cu. ft.	Million bbl.		
1	11	12	13	14	15	16	17	18
3-5-38 to 1-1-42	21.35	194,800	68.5	12.2	65.5	11.6	341	3,139
1-1-42 to 1-1-43	36.35	332,000	117	20.8	107	19.0	405	3,075
1-1-43 to 1-1-45	69.9	638,000	225	40.1	215	38.3	430	3,050
1-1-43 to 1-1-45	72.2	659,000	232	41.3	196	34.9	490	2,990
1-1-43 to 1-1-45	72.7	663,000	233	41.5	188	33.5	505	2,975
1-1-43 to 1-1-45	67.9	620,000	218	38.8	182	32.4	390	3,090
1-1-43 to 1-1-45	80.8	737,000	259	46.1	249	44.3	670	2,810
1-1-45 to 1-1-48	123.0	1,122,000	395	70.3	385	68.5	435	3,045
1-1-45 to 1-1-48	136.4	1,245,000	438	78.0	338	60.1	580	2,900
1-1-45 to 1-1-48	143.3	1,308,000	460	81.9	303	54.0	680	2,800
1-1-45 to 1-1-48	116.2	1,060,000	373	66.4	273	48.5	425	3,055
1-1-45 to 1-1-48	172.2	1,571,000	553	98.5	543	96.7	830	2,650
1-1-48 to 1-1-52	193.0	1,761,000	620	110.4	610	108.6	440	3,040
1-1-48 to 1-1-52	238.4	2,175,000	766	136.4	530	94.4	695	2,785
1-1-48 to 1-1-52	270.4	2,467,000	868	154.6	448	79.8	910	2,570
1-1-48 to 1-1-52	191.4	1,747,000	615	109.5	379	67.5	515	2,965
1-1-48 to 1-1-52	312.4	2,851,000	1,004	178.8	994	177.0	905	2,575

total area (A) under the pressure-decline curve to January 1, 1943, is 36.35 square units or 331,700 (9125×36.35) lb. per sq. in.-days.

The following numerical values correspond to the reservoir pressure of 3075 lb. per sq. in., abs., as of January 1, 1943:

$c=352$; $A=331{,}700$; $w=10.1\times10^6$; $g_b=21{,}680\times10^6$;

$$f_2=\frac{3075\times520}{14.4\times667\times.901}=184.9;$$

$S_2=136.0$; $S_s=1.4$; $n_b=141.5\times10^6$; $F_2=1.435$; $G_1=433.7\times10^6$; $f_1=203.5$; $N_1=2026\times10^6$; $S_1=152.7$; $F_1=1.476$.

Substituting these values for the symbols in equation (i) gives:

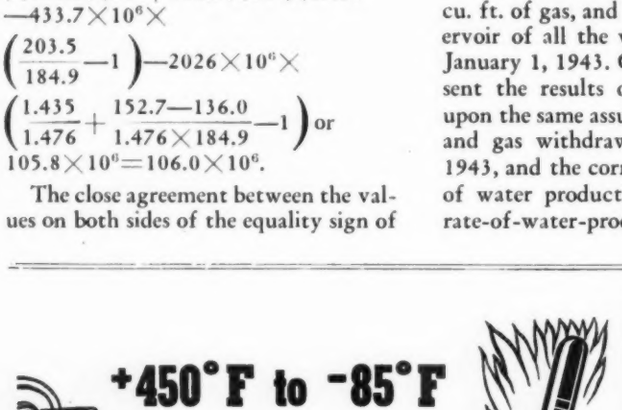
$$352\times331{,}700-10.1\times10^6=\frac{21{,}680\times10^6}{184.9}-\frac{136.0-1.4}{184.9}\times141.5\times10^6+141.5\times10^6\times1.435-433.7\times10^6\times\left(\frac{203.5}{184.9}-1\right)-2026\times10^6\times\left(\frac{1.435}{1.476}+\frac{152.7-136.0}{1.476\times184.9}-1\right)$$

or $105.8\times10^6=106.0\times10^6$.

The close agreement between the values on both sides of the equality sign of the equation indicates that the extrapolated reservoir pressure as of January 1, 1943 (3075 lb. per sq. in., abs.), is approximately correct for the assumed conditions. If the equation had not balanced approximately it would have been necessary to assume another reservoir pressure as of January 1, 1943, and repeat the calculations.

The effect on the reservoir pressure of different rates of fluid withdrawal, or the net effect of different rates of fluid withdrawal when partial restoration of reservoir pressure is effected by the injection of gas or water, can be calculated in a similar manner. The calculated future reservoir pressures based upon five assumed rates of fluid withdrawal are given in Table 20 and shown graphically in Fig. 22. Curve a (Fig. 22) represents the results of calculations based upon an assumed daily rate of withdrawal after January 1, 1943, of 18,800 bbl. of oil and 15,023,000 cu. ft. of gas, and the return to the reservoir of all the water produced after January 1, 1943. Curves b and c represent the results of calculations based upon the same assumed daily rates of oil and gas withdrawal after January 1, 1943, and the corresponding daily rates of water production indicated by the rate-of-water-production curves shown on Fig. 21. Curve d (Fig. 22) represents calculations based upon an assumed daily rate of withdrawal after January 1, 1943, of 18,800 bbl. of oil, 3,756,000 cu. ft. of gas (net), and the corresponding daily rates of water production indicated by curve d (Fig. 21). In calculating curve d (Fig. 22) it was assumed that 75 percent of the 15,023,000 cu. ft. of gas produced daily—the assumption used to derive curves a, b, and c (Fig. 22)—was returned to the Magnolia reservoir. Curve e (Fig. 22) represents the results of calculations based upon assumed daily withdrawals after January 1, 1943, of 37,600 bbl. of oil and 30,046,000 cu. ft. of gas, and the return to the reservoir of all water produced.

The sample calculations are based upon the assumption that the rate of water encroachment was proportional to the difference between the initial and subsequent reservoir pressures. The production data on a number of fields should be studied to establish the validity of this assumption. If the assumption does not hold, perhaps an empirical equation can be derived; and equation (i) still can be used to estimate future reservoir pressures. For example: If the rate of water encroachment was found to be proportional to (P_1-P_2) multi-



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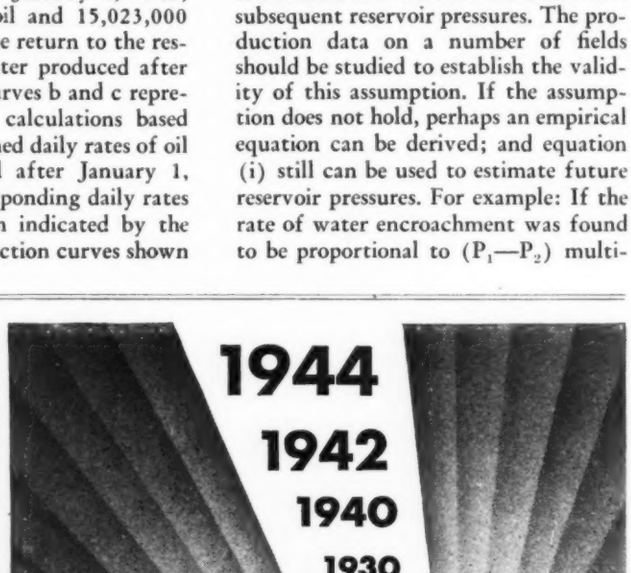

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plied by a known function of the total volume of encroached water W, then, instead of plotting (P_1—P_2) against time as was done in constructing Fig. 22, (P_1—P_2) multiplied by the function of W should be plotted against time, and the values of A and c found as before.

Alternate method of calculating volumes of oil, gas, and encroached water in a petroleum reservoir. If two unknown factors are substituted in two independent equations the unknowns can be determined by solving the equations simultaneously. Therefore, if equation (i) contains only two unknowns they may be evaluated by setting up two equations, using equation (i) to represent conditions in the reservoir on two different dates. Equation (i) is:

$$cA - w = \frac{g_b}{f_2} - \frac{S_2 - S_s}{f_2} \times n_b + n_b F_2 - G_1 \times \left(\frac{f_1}{f_2} - 1\right) - N_1 \left(\frac{F_2}{F_1} + \frac{S_1 - S_2}{F_1 f_2} - 1\right).$$

If, for two specific dates the values of A in equation (i) are determined from a pressure-decline curve; g_b, n_b, and w from production data for the field; S_1, S_2, S_s, F_1, and F_2 from laboratory data on a subsurface oil sample; and f_1 and f_2 from compressibility data for the gas-cap gas, the values of c, G_1, and N_1 are the only unknown factors in the equations. If one of them is equal to zero (c would equal zero if no water moved into the reservoir, G_1 would equal zero if no free gas was in the reservoir initially, and N_1 would equal zero in a gas reservoir) or can be determined from some other source, the other two unknowns can be evaluated if they are set up in two separate equations and the equations are solved simultaneously.

Although unknown values of G_1 and N_1 can be determined mathematically by this method, it is not advisable to do so because the relative expansibility of G_1 is approximately of the same order as the relative expansibility of N_1. This results in determining large values of N_1 and G_1 by small differences. Furthermore, whenever the expansibility of the gas-cap gas (expressed in percent) for two pressure reductions is obtained by multiplying the expansibility of the reservoir oil (expressed in percent) by a constant, equations containing these values cannot be solved simultaneously. For example: Assume that the expansibility of the gas-cap gas resulting from a reduction in pressure from P_1 to P_2 is 3 per cent and from P_1 to P_3 9 per cent, and the expansibility of the reservoir oil from P_1 to P_2 is 1 per cent and from P_1 to P_3 3 per cent, the expansibility of the gas for each pressure reduction is three times as great as the expansibility of the oil. Simultaneous equations set up using expansibilities of the same relative order for N_1 and G_1 cannot be solved because that would be analogous to a simultaneous solution of x and y in the equations: (1), $x+y=3$ and (2), $2x+2y=6$. Therefore, application of this method in reservoir calculations is recommended only when the following conditions can be satisfied: (1) The volume of encroached water is one of the unknowns; (2) the rate of water encroachment is proportional to the pressure decline in the reservoir and a reliable pressure-decline curve can be constructed, or, if the rate of water encroachment is found from some empirical formula and a curve representing the rate of water encroachment can be constructed (see last paragraph of Sample Calculations under Calculations of Future Reservoir Pressures); and (3) the reservoir pressure has been reduced by more than 25 per cent of the initial pressure.

Sample calculation. To calculate the volume of water that had encroached into the Magnolia reservoir to January 1, 1942, and the initial volume of oil in the reservoir, the field and laboratory data given in Part I of this report (except those used to determine the initial volume of oil) and the pressure-decline curve shown in Fig. 22 are used.

Equation (i) then is set up to correspond with the field and laboratory data to and including July 1, 1940, and again to correspond with the field and laboratory data to and including January 1, 1942. For the first equation the area A under the pressure-decline curve (Fig. 22), to July 1, 1940, is 5.81 square units or 53,000 (9125×5.81) lb. per sq. in.-days; for the second equation the area under the pressure-decline curve to January 1, 1942, is 21.35 square units or 194,000 (9125×21.35) lb. per sq. in.-days.

In the two equations to be set up, c and N_1 are the two unknowns. G_1 was

TABLE 20

Calculated volumes of water encroachment and reservoir pressures at future dates for five different assumed production rates

Period	Assumed average daily production rates for indicated period				Assumed cumulative net production to end of period				
					Oil		Gas	Water	
	Letters correspond to curves in Figs. 21-22	Oil, bbl.	Net gas, M. cu. ft.	Net water, bbl.	Million cu. ft.	Million bbl.	Million cu. ft.	Million cu. ft.	Million bbl.
1	2	3	4	5	6	7	8	9	10
3-5-38 to 1-1-42	Actual	Actual	Actual	Actual	103.0	18.35	16,197	3.1	0.547
1-1-42 to 1-1-43	Estimated	18,800	15,023	3,400	141.5	25.21	21,680	10.1	1.8
1-1-43 to 1-1-45	a	18,800	15,023	0	218.5	38.92	32,646	10.1	1.8
1-1-43 to 1-1-45	b	18,800	15,023	6,270	218.5	38.92	32,646	35.8	6.4
1-1-43 to 1-1-45	c	18,800	15,023	8,490	218.5	38.92	32,646	44.9	8.0
1-1-43 to 1-1-45	d	18,800	3,756	6,270	218.5	38.92	24,422	35.8	6.4
1-1-43 to 1-1-45	e	37,600	30,046	0	295.6	52.64	43,612	10.1	1.8
1-1-45 to 1-1-48	a	18,800	15,023	0	334.1	59.51	49,095	10.1	1.8
1-1-45 to 1-1-48	b	18,800	15,023	10,500	334.1	59.51	49,095	100.5	17.9
1-1-45 to 1-1-48	c	18,800	15,023	18,170	334.1	59.51	49,095	156.6	27.9
1-1-45 to 1-1-48	d	18,800	3,756	10,500	334.1	59.51	28,535	100.5	17.9
1-1-45 to 1-1-48	e	37,600	30,046	0	526.8	93.84	76,510	10.1	1.8
1-1-48 to 1-1-52	a	18,800	15,023	0	488.2	86.96	71,027	10.1	1.8
1-1-48 to 1-1-52	b	18,800	15,023	16,500	488.2	86.96	71,027	235.8	42.0
1-1-48 to 1-1-52	c	18,800	15,023	32,125	488.2	86.96	71,027	419.9	74.8
1-1-48 to 1-1-52	d	18,800	3,756	16,500	488.2	86.96	34,019	235.8	42.0
1-1-48 to 1-1-52	e	37,600	30,046	0	835.1	148.75	120,374	10.1	1.8

Period	Area under pressure-decline curve to end of period		Calculated cumulative volume of encroached water at end of period				Calculated decline in reservoir pressure at end of period, lb. per sq. in.	Calculated reservoir pressure at end of period, lb. per sq. in., abs.
			Total (W)		Net (W_e)			
	Sq. units	Lb. per sq. in.—days	Million cu. ft.	Million bbl.	Million cu. ft.	Million bbl.		
1	11	12	13	14	15	16	17	18
3-5-38 to 1-1-42	21.35	194,800	68.5	12.2	65.5	11.6	341	3,139
1-1-42 to 1-1-43	36.35	332,000	117	20.8	107	19.0	405	3,075
1-1-43 to 1-1-45	69.9	638,000	225	40.1	215	38.3	430	3,050
1-1-43 to 1-1-45	72.2	659,000	232	41.3	196	34.9	490	2,990
1-1-43 to 1-1-45	72.7	663,000	233	41.5	188	33.5	505	2,975
1-1-43 to 1-1-45	67.9	620,000	218	38.8	182	32.4	390	3,090
1-1-43 to 1-1-45	80.8	737,000	259	46.1	249	44.3	670	2,810
1-1-45 to 1-1-48	123.0	1,122,000	395	70.3	385	68.5	435	3,045
1-1-45 to 1-1-48	136.4	1,245,000	438	78.0	338	60.1	580	2,900
1-1-45 to 1-1-48	143.3	1,308,000	460	81.9	303	54.0	680	2,800
1-1-45 to 1-1-48	116.2	1,060,000	373	66.4	273	48.5	425	3,055
1-1-45 to 1-1-48	172.2	1,571,000	553	98.5	543	96.7	830	2,650
1-1-48 to 1-1-52	193.0	1,761,000	620	110.4	610	108.6	440	3,040
1-1-48 to 1-1-52	238.4	2,175,000	766	136.4	530	94.4	695	2,785
1-1-48 to 1-1-52	270.4	2,467,000	868	154.6	448	79.8	910	2,570
1-1-48 to 1-1-52	191.4	1,747,000	615	109.5	379	67.5	515	2,965
1-1-48 to 1-1-52	312.4	2,851,000	1,004	178.8	994	177.0	905	2,575

determined from cores and electric logs. The information required to complete the remainder of equation (i) to correspond with the production to July 1, 1940, was obtained from the gas-liberation curves (Fig. 14) and from the production data given in Part I of this report. Thus, P_1=3480 lb. per sq. in., abs.; P_2=3303 lb. per sq. in., abs.; T_1 and T_2=667°F., abs.; w=0.1×10^6 cu. ft; g_b=6650×10^6 cu. ft.; f_2=$\frac{3303\times520}{14.4\times667\times.915}$=195.3; S_2=145.6 cu. ft. of gas per cu. ft. oil; S_s=1.4 cu. ft. of gas per cu. ft. oil; n_b=42.0×10^6 cu. ft.; F_2=1.458; G_1=433.7×10^6 cu. ft.; f_1=203.5; S_1=152.7 cu. ft. of gas per cu. ft. oil, and F_1=1.476.

Substituting these values for the corresponding symbols in equation (i) gives $c\times53{,}000-0.1\times10^6=$

$$\frac{6650\times10^6}{195.3}-\frac{145.6-1.4}{195.3}\times42.0\times10^6+42.0\times10^6\times1.458-433.7\times10^6\left(\frac{203.5}{195.3}-1\right)-N_1\times\left(\frac{1.458}{1.476}+\frac{152.7-145.6}{1.476\times195.3}-1\right);$$

simplifying, (1) $53{,}000c+0.0124N_1=46.2\times10^6$.

Except for the values of A, c, and N_1, required for substitution in equation (i) as of January 1, 1942, fluid production and correlative data were determined from Table 19 to be: P_1=3480 lb. per sq. in., abs.; P_2=3139 lb. per sq. in., abs.; w=3.1×10^6 cu. ft.; g_b=$16{,}197\times10^6$ cu. ft.; f_2=187.8; S_2=138.4 cu. ft. of gas per cu. ft. oil; S_s=1.4 cu. ft. of gas per cu. ft. oil; n_b=103.0×10^6 cu. ft.; F_2=1.442; G=433.7×10^6 cu. ft.; f_1=203.5; S_1=152.7 cu. ft. of gas per cu. ft. oil, and F_1=1.476. The value of A was found from the pressure-decline curve to be 194,800 lb. per sq. in.-days.

Substituting these values for the symbols in equation (i) gives: (2) $194{,}800c+0.0286N_1=126.4\times10^6$.

A simultaneous calculation of the two equations: (1) $53{,}000c+0.0124N_1=46.2\times10^6$ and (2), $194{,}800c+0.0286N_1=126.4\times10^6$, gives c=273 cu. ft.—the volume of water that entered the reservoir per lb. per sq. in. pressure-decline per day—and N_1=2560×10^6 cu. ft.—the volume of initial reservoir oil.

The total volume of water that had encroached into the reservoir on January 1, 1942, is represented by c × A. As A was calculated to be 194,800 lb. per sq. in.-days and c was found to be 273 cu. ft. per lb. per sq. in. pressure-decline per day, the total volume of encroached water W is 273 × 194,800 or 53.2×10^6 cu. ft.

It is readily apparent that the values for N_1 and W are not in close agreement with those previously calculated and showing N_1 to equal 2026×10^6 cu. ft. and W to equal 68.5×10^6 cu. ft. However, when the suggested method is applied to reservoirs in which the percentage pressure decline is larger than that in the Magnolia reservoir to January 1, 1942, the results probably will agree more closely. In this example the pressure decline from date of discovery to January 1, 1942, was only 9.80 per cent.

The discussed method of calculating the volume of initial oil in place and the volume of water that has encroached by a subsequent date, or the volume of the initial gas in place and the volume of water that has encroached by a subsequent date, may be in serious error for some fields in which the assumption that the rate of water encroachment is proportional to the reservoir-pressure decline does not hold true. It is believed, however, that the method may be useful where the available data are inadequate to make any other scientific calculation. Many gas fields, for example, are not sufficiently developed to furnish the necessary data for estimating the volume of the initial gas by the porosity-volume method; and for fields in which water encroaches, the volume of the initial gas, as calculated by this method, probably would be more reliable than a calculation based upon production data, changes in reservoir pressure, and constant reservoir volume.

Conclusions

Equations based upon a material balance of fluids in petroleum reservoirs have been derived in this report to calculate the volumes of oil, gas, and encroached water in the reservoir and to indicate the changes that occur in their respective volumes during any period of time following the commencement of production. The use of equations for calculating reservoir pressures on future dates corresponding with different methods of field operations, and examples showing the application of the equations to data on the Magnolia field, Arkansas, to indicate the changes in volumes of the oil, gas, and encroached water with time have been presented.

It is shown in the report that the volumes of oil and gas initially in the reservoir or the volume of water that has entered the reservoir by a certain time can be calculated, provided any two of these three volumes and certain field and laboratory data are known. The essential field data needed in the calculations include: The initial reservoir pressure and temperature; cumulative oil, gas, and water production; the average separator pressure and temperature during their production; and the average reservoir pressure and temperature on the date corresponding to the cumulative productions. The laboratory data required are P-V-T relations for the free gas, including compressibility factors, and solubility and shrinkage data for the reservoir oil, which should be collected in such a way that the liberated gas and the shrinkage of the oil between the reservoir and the gas-oil separator can be calculated in terms of volumes of stock-tank oil. The material-balance equations given in this report also can be used to calculate the volumes of fluids in some reservoirs that initially contained oil undersaturated with gas; but the calculations are complicated, and the results obtained are not always reliable.

Material-balance equations may be used to calculate future reservoir pressures corresponding to different future rates of oil production and to show the effect of the injection of gas or water on reservoir pressures when reliable estimates of corresponding rates of gas and water production can be made. A material-balance study of petroleum reservoirs, therefore, is an aid in determining future production rates, allowable upper limit of gas:oil ratios, and the feasibility of returning produced or extraneous water or gas to the reservoirs.

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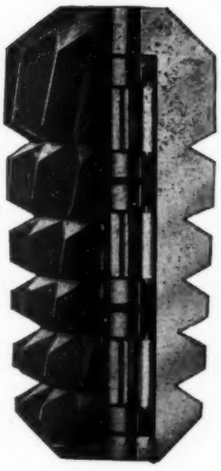

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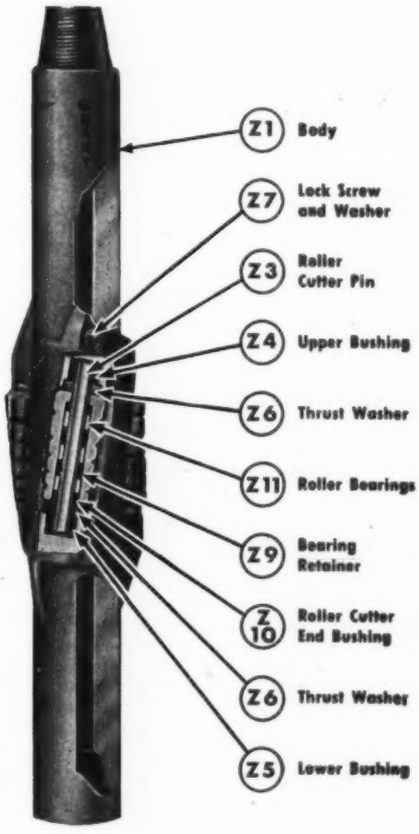

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DR. EUGENE R. SMOLEY

"I'D LIKE to give you a thumb nail picture of the one engineering field where I'm at home; the petroleum refining industry. It makes a good case-history, because its advancement has been super-great, yet the men in it know that much greater attainment lies ahead.

"When we left Technology in 1919, the refining of crude petroleum to gasoline and lubricants was done by pot still distillation. The standard of efficiency was no greater than that achieved by the maker of moonshine in the Kentucky hills, maybe not as good.

"A million barrels of crude then yielded about 200,000 bbl. of gas. Today the yield is about 500,000; and crude production is up about 4½ times.

Dr. Eugene R. Smoley of the Lummus Company was selected by Massachusetts Institute of Technology to deliver the "25 Year Speech" to the class of 1944 at class day exercises on February 26. Dr. Smoley is a graduate of M.I.T., class of '19. Much of the speech was devoted to a discussion of the petroleum refining industry, its progress during the last 25 years and its wartime developments. Because of the interest it has for those in the industry, that part of his speech is quoted.

"But such figures tell an incomplete story. Because the power value also has gone 'way up. A petroleum engineer is a sort of fuel bartender. He mixes a power cocktail, and measures its potency by octanes.

"The old Model T Ford, the early single engine flying crate—they knocked along on a 50-octane gasoline. Improved methods brought the rating up to 70. Then in 1927, the discovery of the efficiency addition of tetraethyl added another 15 points. In the 1930's, the process of catalytic cracking served to open a way to make high octane gas in large volume.

"The engines were hungry for it, and like any greedy thing, be it animal or machine, responded gratefully to those who provided what was wanted. In the Battle of Britain in 1940, the period referred to by Winston Churchill when he said that never in the field of human conflict was so much owed by so many to so few, the British airplanes were powered with 100-octane gasoline supplied by the United States. The Germans used an 87-octane gas. The resultant advantage in British maneuverability, rate of climb and altitude possibility had much to do with the result.

"Gasoline supplies were and still are a war factor of major importance. We took it on the chin plenty at the start of our own war participation. In my mind's eye I can see now a refinery in Sumatra, for I lived three years in that Netherlands East Indies locality. It was a splendid plant, producing 100-octane aviation gasoline and other war products. When the Japs attacked, they sent paratroopers there as a first order of business. On that particular job they failed. The 50,000 bbl. per day refinery was destroyed in toto before it could be captured. An entire 125-mile pipe line system to the wells, all the drilling and production equipment; all tools, motors and instruments—all were sledged or torched. Furnaces and boilers were melted to slag. Lines were dynamited, wells cemented, fireproofing removed from supports, pits flooded with oil, then fired. This destruction was supervised by Americans, who then made their getaway with only a few hours leeway. But remember, the oil production was lost to us as well as to the Japs.

"Other destruction attempts were not so successful. The Japs did capture other refining sources, and have been using them.

"From the war's beginning, our war leaders knew that however much everything else would be needed, aviation gasoline would be required in hitherto undreamed of quantities. Today it is easy to form a mental picture of such requirements. Two thousand bombers raiding Berlin from bases in England use 100,000 bbl. of 100-octane aviation fuel. This is equivalent to six months' production in 1937.

"It isn't only in gasoline requirements that petroleum engineers have been called on to meet war's need. They found a way to make toluol for TNT. No longer is there a threat of a shortage so far as this war is concerned.

"And rubber? That might have been like an Achilles heel for the United Nations except for such men as the M.I.T. has been furnishing to industry through the years. The chemical and oil technologists met this gravest of challenges. When some future word wizard tells the story of industry in this war, the recital of synthetic rubber manufacture will be among his most fascinating tales.

"Well, as you know, what the oil industry has been doing in this war, every other industry has done in its own field. The accomplishment of American producers has been so great that it will take years for us to realize its full import. We need perspective to really grasp what has been done. But we require no lapse of time to know that this wonderful achievement came not only from nature's bounty in material wealth. Rather, it came from the minds of men, of men trained in the way the members of your class have been trained.

"When engineers get off by themselves and try to look objectively at the world in the manner they're accustomed to viewing their task, they sometimes wonder why so much of their work is

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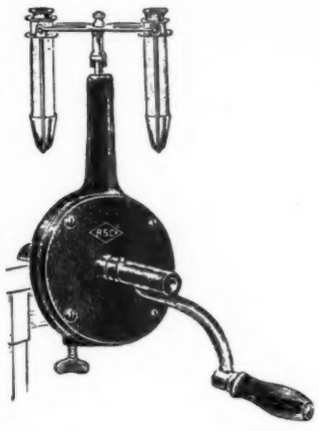

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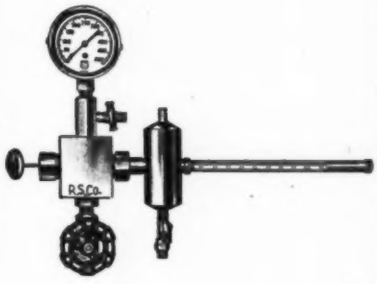

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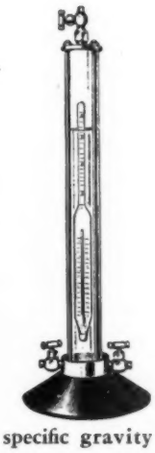

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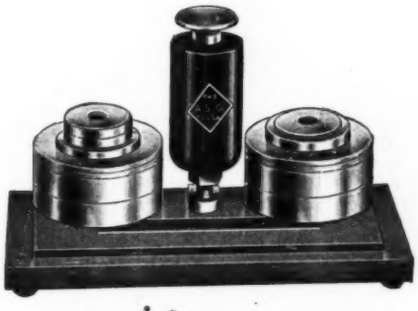

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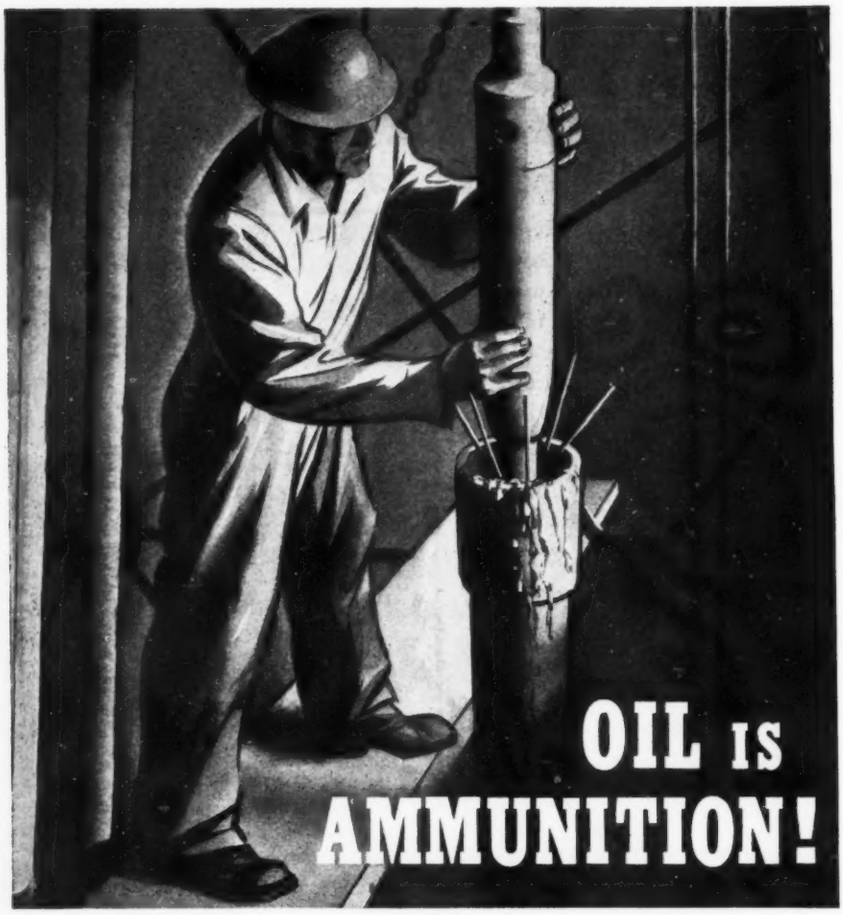

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put to destructive use. They don't know how to explain it.

"Well, neither does anybody else. We engineers must remember that our vocation started in war. There were military engineers before there were civil engineers or any other sort. In a literal sense, we came out of war.

"Yet, it is a confession of human failure when we have to return to it. Not engineering, but generally human failure! The depression of the thirties, like today's war, is a symptom of illness in human relations. Perhaps it points a duty to engineers; a duty to take part in the world of deliberative councils as well as practical problems.

"Particularly America's engineers! Our country will emerge from this war as the strongest national entity that ever has existed. With such power goes great responsibility. If our engineers help to exercise that responsibility in matters of international decision, perhaps they can determine that the work of their minds and hands will be peacefully directed to the good of mankind.

"There is a tremendous amount of work to be done. The engineer, always needed, will be more than ever in demand. I am not so sure that he will be permitted to be as much of an individualist as formerly. I am not at all certain that his will be the opportunity to amass great wealth. But that is not an engineering problem. It is a condition resulting from social changes, which the war has not brought about though it has greatly accelerated their development.

"If the engineer is not permitted to get rich, he'll be in the same boat with everybody else. Whence then will come his satisfaction?

"I believe, and I'm sure you all will agree, that of all classes of men, classifying them by the nature of the work they do, none is more important than the engineer. Few are as important. It is the engineer who eases the physical load of life, improving contact, making living brighter, more healthful, more enjoyable, more useful. There is an immeasurable amount of all this which needs doing.

"Thus, by what the engineer does, he has a grand chance to lead a life equal in its opportunity for happiness to that of the most fortunate. And what makes a happy life? What does a man want most?

"I read an interview some years ago in which Albert Einstein was asked that question, and I give you his answer:

" 'A man, more than anything else, wants the good regard and approval of the men in the field in which he works.'

"I hope all of you get it."

——— ☆ ☆ ☆ ———

Brown Assistant Sales Manager

Le Roi Company, Milwaukee, Wisconsin, announces the promotion of Cecil Brown to assistant sales manager. Brown has been active in various capacities with Le Roi since 1938. With 13 years of experience behind him, he came to Le Roi as chief draftsman of air compressors.

CECIL BROWN

With the advent of the war, Brown asssumed such duties as setting up and operating the expediting and priority department. Later he was transferred to supervisor of assembly and test. When the job of field engineer became necessary, Brown was asked to take over the job.

Bradie Heads Sand-Banum

The American Sand-Banum Company, Inc., of 9 Rockefeller Plaza, New York City, announces the election of Louis Bradie to the office of president of the corporation to fill the vacancy created by the death of former president, George A. Kubler.

Enlarging Laboratory

Laboratory facilities of the Houdry Process Corporation, Wilmington, Delaware, are being expanded, Eugene J. Houdry, president, has announced.

The new addition will add floor space to the main research laboratories of Catalytic Development Corporation, Linwood, Pennsylvania.

"The continuing research into the catalytic transformation of petroleum has brought about the essential need for increasing our research facilities. To this end an extension of brick and reinforced concrete is being added to our present building," Houdry said. "The new extension will permit additional working space to accommodate chemists, technicians, engineers, and assistants. Upon completion, most of the corporation personnel will be headquartered at the Linwood laboratories, under the corporation's operating subsidiary, the Catalytic Development Corporation."

R. W. Owens Joins Elliott

R. W. Owens has been appointed assistant to the president of Elliott Company, according to announcement by Grant B. Shipley, president of the Jeannette, Pennsylvania, firm.

A native of Morris, Illinois, and a graduate of the University of Illinois with a B.S. degree, Owens received an M.S. degree from the same university in 1915 before joining the staff of Westinghouse. Successively a section engineer, manager of the industrial motor engineering department, general manager of industrial engineering, and manager of the motor division in complete charge of engineering, manufacturing and sales, he brings to Elliott Company 28 years of practical design experience.

New Houston Office

Herschel J. Wood has been appointed southwestern representative of the Lebanon Steel Foundry, Lebanon, Pennsylvania. He will be in charge of this company's new office at 1505 Commerce Building, Houston, Texas.

H. J. WOOD

Wood was formerly associated with the Elastic Stop Nut Corporation of America. His appointment was effective February 1.

Lebanon Steel Foundry's office will handle engineering, sales, and service to customers in the Southwest.

Grand Slam of "E's"

Unusual recognition for outstanding war production is noted in the announcement that The Cooper-Bessemer Corporation, with plants at Mount Vernon, Ohio, and in Grove City, Pennsylvania, is to be awarded the Army-Navy "E."

This new honor will complete a grand slam in government awards that began August 29, 1942, with presentation of the United States Treasury Department's Minute-Man flag for 100 per cent participation of its employees in War Bond subscription, followed by award of the Maritime Commission's "M" burgee on December 18, 1942, for outstanding production of diesel engines and major engine parts for which they have subsequently received two gold stars for continued achievement on August 3, 1943, and January 25, 1944.

Secretary National Tube

R. Heath Larry has been elected secretary of the National Tube Company, U. S. Steel subsidiary, to succeed the late E. W. Criswell. His offices are at Pittsburgh, Pennsylvania.

Major Southwest headquarters of National Tube Company are in Dallas, Houston, and Tulsa.

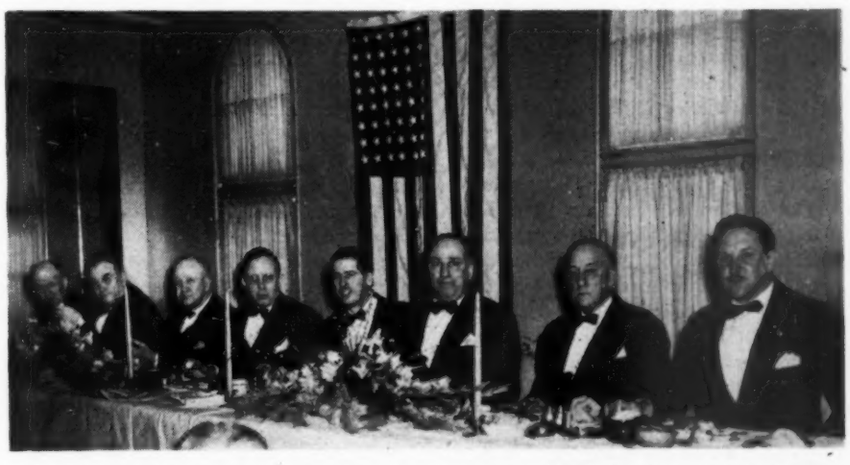
Tulsa Nomads' Dinner

The annual dinner meeting of Tulsa Chapter Nomads was held on Monday night, February 14, in the Tulsa Club, preceded by a reception for members and guests from 6:30 to 8 p. m. The election committee announced the result of the balloting for officers for 1944 as follows:

President, G. W. (Jack) Walton; vice president, Shep Miers; secretary-treasurer, H. M. Cosgrove; sergeant-at-arms, A. G. Bailey; regents, C. O. Willson and P. E. Fitzgerald.

There was a large attendance of members and guests at the dinner, at which W. G. Green acted as toastmaster. D. R. Davis, U. S. Rubber Company, Tulsa, gave an illustrated talk on "Prospecting for Oil in Egypt."

Secretary-treasurer Cosgrove, re-elected, was presented a gold Longines wrist watch as a tribute of appreciation from the members. Retiring President Fitzgerald received a gold pen and pencil pocket set.



Paul E. Fitzgerald, regent; W. G. Green, past president; G. W. Walton, president; H. M. Cosgrove, secretary-treasurer; D. R. Davis, speaker. Left to right: C. O. Willson, regent; Fred E. Cooper, past president; A. G. Bailey, sergeant at arms;

Design and Metallurgy— The Vital Factors of Tool Construction

☆ **Tests made on materials and products provide operators with tools that can be used with confidence**

by Garth F. Nicolson and M. B. Riordan

Chief Engineer and Chief Metallurgist, Oil Tool Division, Byron Jackson Company

OIL tools are the products of men and materials; but the quality of tools — their ability to perform most efficiently, to withstand rough usage, to provide economical maintenance and to have a long, useful life—depends on design, metallurgy and workmanship. It is comparatively easy to make a tool that will do a job by main strength and awkwardness; but it takes skill, knowledge and facilities to build into a tool maximum performance with greatest convenience and to make the operation of that tool coordinate with all the other equipment employed on a drilling rig. The manufacturer should furnish the operator a tool that will not only do the job most efficiently and economically but will also instill confidence in its use because of its engineered design and construction.

It is the aim of Byron Jackson Company to provide the oil industry with tools that embody every feature of efficient performance, safety, economy and confidence in operation. This has necessitated experience in design, metallurgical research, the application of sound metallurgy in construction, and the testing both of the materials to be used and of the finished product. A considerable amount of laboratory and shop equipment have had to be installed to meet these requirements but the company has even gone further and has recently installed a complete drilling rig at the Vernon Plant for field testing new developments in oil tool design and to check old designs in meeting the demands of advanced drilling technique.

The parts of all BJ tools are heat treated and the heat treatment, material specifications and control are determined by the Jominey Test. This test makes it possible to determine the proper types of steel to use for various parts of tools and to provide metallurgical control so that each lot of steel meets specifications.

Although a tool may be heat treated, there are various points that are subject to extreme wear. In Byron Jackson tools these places are hardened by flame hardening—a process by means of which the metal is locally heated by an oxy-acetylene flame and then subjected to a suitable quench, usually a stream of water. This produces a hard steel surface on the tough, more ductile body of metal below. Parts are then hardened only where extra hardness is desired and the depth to which the surface is hardened is controlled. The flame hardening does not change the chemical composition of the steel in any way.

G. F. NICOLSON

M. B. RIORDAN

GARTH F. NICOLSON was graduated from California Institute of Technology as a B.S. in M.E. in 1934, and immediately went to work for Byron Jackson Company, in the service and engineering departments. He was made Chief Engineer, Oil Tool Division, in 1942.

M. B. RIORDAN took chemical engineering at the University of Southern California, and was graduated with the degree of B.S. in 1939. After spending two years with Wilshire Oil Company on chemical control in refining operations, he went with Byron Jackson Company in the metallurgical department. In 1943 he was appointed Chief Metallurgist of that company.

The design of a tool must not only provide for the best possible performance in doing the job for which it was designed but should also eliminate excess material which, in addition to being wasteful, may frequently be detrimental in operation. To aid in design, as well as proving the capacity of the finished product, Byron Jackson employs Electric Strain Gauges that determine the stress-strain relationship of all parts. The data furnished by this equipment enables the designer to put strength where it is needed and to eliminate material where it serves no useful purpose. The "ideal" design is thus possible and the required capacity (with ample factor of safety) is secured without excess weight.

Metallurgical control is carried further by use of wide field microscopes for metal examination and surface inspection. Such inspections are followed by Metallagraph determinations. All springs and other vital parts are individually inspected with Magnaflux equipment. Other specific problems are subjected to metallurgical research and the data obtained are utilized in the design and improvements of tools. As advancements in drilling technique occur, the facilities of the Byron Jackson organization are utilized to develop tools to meet the new requirements.

The adaptation of advanced metallurgy, the utilization of test data and the details of design of the various, individual oil tools manufactured by Byron Jackson Co. will be discussed in a series of articles, the first of which—on Triplex Hooks—follows.

This series of articles is the result of repeated requests for technical details from operating petroleum engineers to the field representatives of the company. Although these service men always have supplied practical information and recommendations, it is felt that an open discussion of the design and metallurgy of BJ Oil Tools should be addressed to all petroleum engineers direct by the engineering personnel of the Oil Tool Division of Byron Jackson Co.

Metallurgy, Testing and Design of BJ Triplex Hooks

The "Triplex" Hook consists of three separate hooks: a larger lower hook for carrying the swivel bail in a true, centrally-balanced position; and two upper hooks, one for each elevator link. This design offers the following advantages over the "connector" design: (1) no stocks of various sized swivel bail adapters are necessary; (2) no time is lost in

(Advertisement)

changing adaptors; (3) no clevis and clevis pin is required to use a single bailed elevator; (4) the Triplex body can be used as a connector and the swivel bail is always available for an emergency job; and (5) less parts are subjected to load in drilling so there are consequent savings in link and elevator life.

The hooks are made with a factor of safety of 4 on the ultimate strength of the material and thus conform to the proposed A.P.I. rating. The curved sections in bending are designed by the Bernoulli-Euler Curved Beam Method which has given results that compare most favorably to those shown by physical strain gauge analysis and destruction tests. Sections subjected to stress concentrations are calculated and checked by physical tests and are included in the design factor of safety. Sections that must resist wear, such as the shank pin hole in the shank, are made strong enough to accommodate a bushing when the hook is overhauled.

Fig. 1. Flame hardening bearing surface of elevator

Design of Parts

The springs of the BJ Triplex Hook are designed with low stress, thus insuring long life. The open coil end design makes possible closer control of maximum stress and saves length which is at a premium in short masts and derricks.

Large capacity thrust bearings are provided to withstand heavy drilling loads and to increase the life of the bearings.

The nut shoulders on the shank, removing bending stresses in the shank threads; see Fig. 6. These threads are of a specially designed acme form with a full radius in the root to minimize stress concentration. Left hand threads tend to shoulder the nut under drilling torque — instead of backing it off. A jam nut locks the shank nut and eliminates troubles encountered with pin through threads. Threads on the shank and nut are cadmium plated to elimi-

Fig. 2. Examining steel under wide-field microscope

Fig. 3. Equipment for making Jominey Test

Fig. 4. Stress-strain test of body of Triplex Hook

(Advertisement)

nate possibilities of galling or rusting in humid climates. The shank pin and hole are flame hardened to resist wear and enough section is provided in the shank to install a bushing when badly worn.

The swivel lock is made with ample bearing area in housing pockets and a rigid shaft insures long trouble-free life. The square section on the shank and in the swivel sleeve offers the best design for heavy service.

One of the most important features of the "triplex" design is the shank pin, which provides flexibility between the shank and the body, equalizing the load on each link and eliminating bending moments in the shank and drill pipe or casing thread. This is considerable when mis-mated links are used. (This feature also is provided in the BJ Duplex body design). The link hook locking arms are securely fastened by a sturdy pin in double shear.

The swivel hook locking arm has a saddle type closing finger which takes the wear rather than the body. This eliminates the sticking of the old style closing fingers when the body is upset by the swivel bail and provides greater contact surface for the bail. The sturdy latch and latch lock on the locking arm prevent the swivel bail jumping from the hook on fishing jobs.

The housing design permits direct-connection to a majority of traveling blocks. By the use of an adaptor (available from block manufacturers) the hook can be direct-connected to all other types.

Adequate means are provided to lubricate all moving surfaces.

Fig. 5. Triplex Hook for 60-ton loads

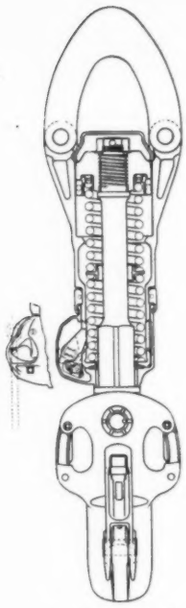


Fig. 6. Detail of Triplex Hook

Metallurgy and Testing of Triplex Hooks

Every part of the BJ Triplex Hook is heat treated to give the maximum tensile and impact properties. Each part is subjected to 100 per cent inspection after heat treatment to insure proper specification.

Heat treatment, material specification and control are determined by the Jominey Test, which insures proper heat treating results in very large sections. This gives complete overall control and assures that each part treated will meet specifications.

Points of extreme wear are flame hardened. This produces a hard, wear-resisting surface and at the same time retains the high tensile and impact properties in the core of the part. Pins, pin holes and bearing races of the hook are all flame hardened.

In order to determine the material and heat treatment required to do the best job with a high factor of safety in a given part, strain tests are made using the recently developed electric strain gage. With this instrument it is possible to determine the amount of stress in a part and its direction and location. It is then easy to determine the ideal combination of design, material and heat treatment to give the best product with a high factor of safety, without the excess weight of overdesign.

Because the hook parts are carefully controlled in manufacture and treated to give their maximum properties, repair work should be done by Byron Jackson Co., either at its Houston or Los Angeles factory. Arrangements can be made through any good supply store. Field welding without the proper preheating, stress relieving, and proper rod, will invariably lead to failures. Highly stressed parts should be re-normalized after two or three years service to increase the fatigue life of the part.

It is impossible to present herein complete details on the design, metallurgy and testing of Triplex Hooks. Further information, however, will be gladly furnished by Garth F. Nicolson, Chief Engineer, Oil Tools Div., Byron Jackson Co., P. O. Box 2017 Terminal Annex, Los Angeles 54, California.

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Fig. 7. Magnaflux examination of Triplex Hook body

Fig. 8. Triplex Hook spring on Magnaflux equipment

Fig. 9. Cadmium plating threads on shank of Triplex Hook

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Maintaining Electrical Control Equipment

PETROLEUM ENGINEER Exclusive Feature

☆ **Preventive maintenance is a "must" for the duration**

by E. H. Lamberger, Petroleum Engineer
and
L. E. Markle, Motor Control Engineer
Westinghouse Electric & Manufacturing Company

GENERATORS and motors without control equipment that functions are useless tools. It was important originally to select the control properly to accomplish the desired starting, speed control, stopping, and various automatic functions. The continued satisfactory performance of the control equipment requires periodic routine inspection and maintenance, just as is required for the rotating apparatus. Neglect of one type of equipment is like permitting a weak link to develop in a chain.

An inspection and maintenance program, backed by an adequate supply of renewal parts, should be set up for the control equipment to match that established for the rotating apparatus.

This article deals principally with contactors and relays, which are vital parts of almost any control equipment.

Do not lubricate bearings. Oil and grease should never be applied to the bearings of a contactor or relay. Experience has indicated that oil or grease will cause dirt to accumulate and eventually result in a sticky, gummy accumulation that causes sluggish action. The bearings are designed with these requirements in mind and no lubrication is required on any part.

Bearing parts should permit contactors or relays to operate freely and without apparent friction. If parts are out of alignment and excessive friction does exist, it should be eliminated. Sluggish action will cause electrical troubles. Monthly inspections for severe service, as on drilling rigs, and semi-annual inspections for average service will do much to prevent bearing and friction troubles.

Some contactors and relays do not have bearings. When the moving parts of a contactor or relay are relatively light the magnetic forces can be made strong enough to lift the movable parts

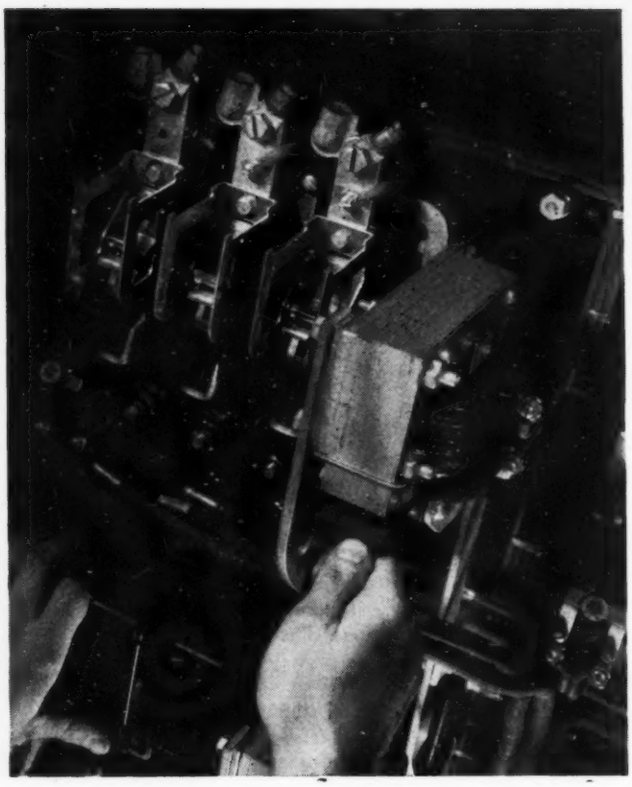
Close-up view of d-c. contactor

CHECK CHART FOR MOTOR STARTER TROUBLE

TROUBLE	CAUSE	WHAT TO DO
Contactor or relay does not close	No supply voltage	Check fuses and disconnect switch
	Low voltage	Check power supply. Wire size may be too small
	Open circuited coil	Replace
	Push button contacts not making	Clean and replace if badly worn
	Interlock or relay contact not making	Adjust and replace if badly worn
	Loose connection or broken wire	Check circuit with flashlight (turn off power first!)
	Overload relay contact open	Reset
Contactor or relay does not open	Push button not connected correctly	Check connections with wiring diagram
	Shim in magnetic circuit* worn, allowing residual magnetism to hold armature closed	Replace
	Interlock or relay contact not opening circuit	Adjust contact travel
	"Sneak" circuit	Check control wiring for insulation failure
	Contacts well shut	See "Contacts weld shut"
Contacts weld shut	Insufficient contact spring pressure causing contacts to burn and draw arc on closing	Adjust, increasing pressure Replace if necessary
	Rough contact surface causing current to be carried by too small an area	Smooth surface and replace if badly worn
Arc lingers across contacts	If blowout is serious, it may be shorted If blowout is shunt, it may be open circuited	Look at wiring diagram and see kind of blowout. Check to see if circuit through blowout is all right
	If used, arc box might be left off or not in correct place	See that arc box is on contactor as it should be
	If no blowout used, note travel of contacts	Increasing travel of contacts will increase rupturing capacity
Noisy a-c. magnet	Improper seating of the armature	Adjust
	Broken shading coil	Replace
Excessive corrosion of contacts	Chattering of contacts as a result of vibrations outside of the control cabinet	Check control pressure and replace spring if it does not give rated pressure. If this does not help, move control, so that vibrations are decreased
	High contact resistance because of insufficient contact spring pressure	Replace contact spring
Abnormally short coil life	High voltage	Check supply voltage and rating of controller
	Gap in magnetic circuit†	Check travel of armature. Adjust so that magnetic circuit is completed
	Too high on ambient temperature	Check rating of contact. Get coil of higher ambient rating from manufacturer if necessary
Panel and apparatus burned by heat from starting resistor	Motor being started too frequently	Use resistor of higher rating

* D-c. only † A-c. only

Moving parts of contactors and relays must move freely and without evidence of undue friction. Bearings are made for severe duty and should not be oiled or greased

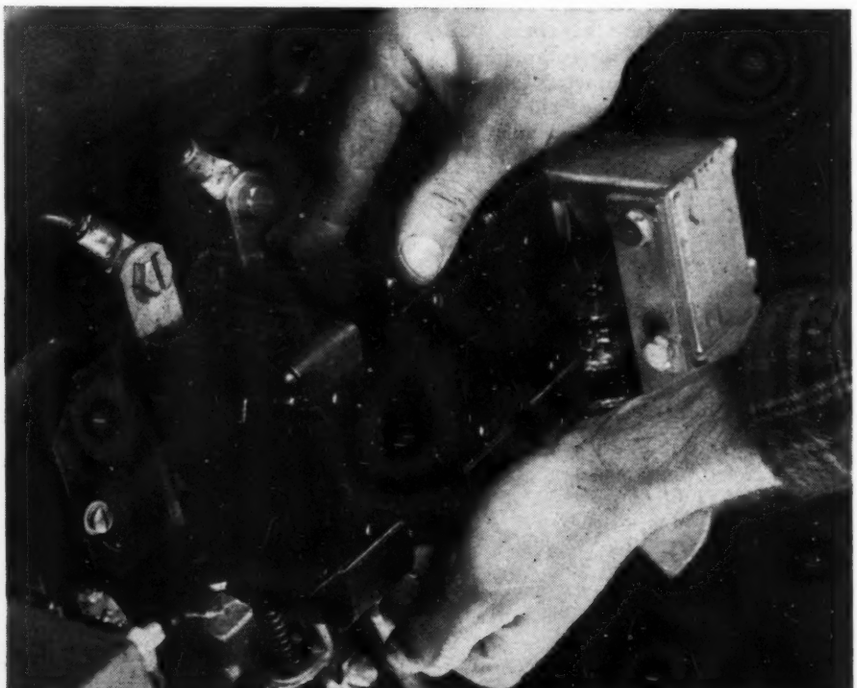


Contacts worn through by long use or badly burned contacts must be renewed. Surfaces against which contacts are bolted should be cleaned. Be sure contacts are tight

vertically to close the contacts. This is an ideal design as it eliminates pivot bearings. However, the moving parts must be guided within the solenoid. Non-magnetic guides must be used to prevent magnetic sticking and sluggish action, and the guides must be kept reasonably clean.

Replace badly pitted or thin contacts. Although contacts are generally thought to be subjected primarily to electrical duty the mechanical duty is equally important. Endurance tests

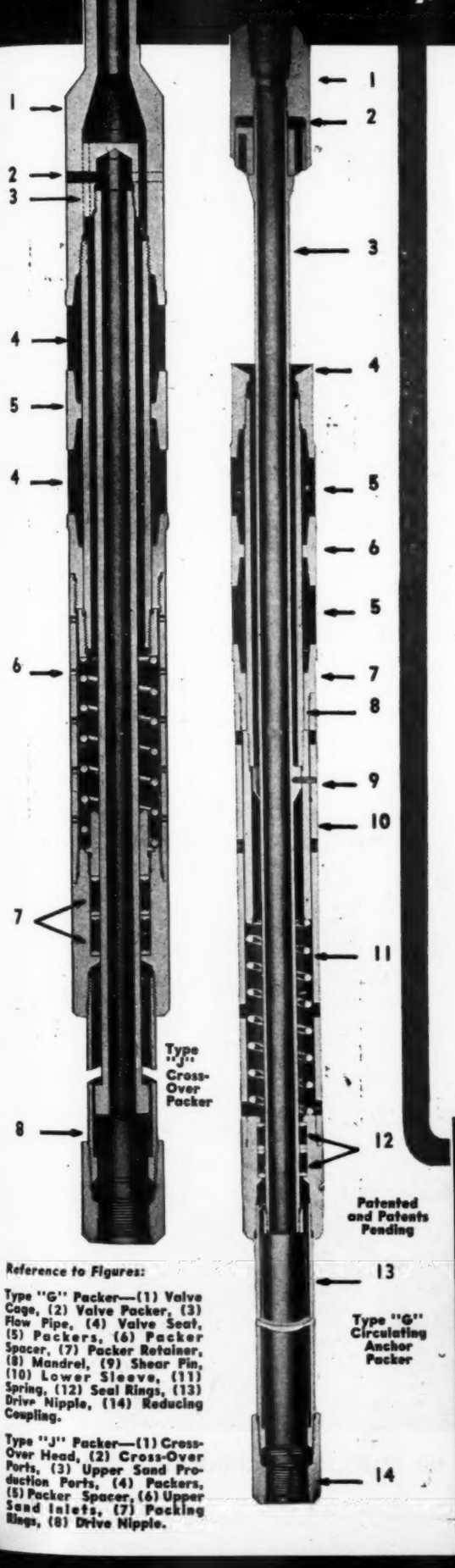
Defective coils must be replaced. Designs are usually made so that coils may be changed easily and quickly



Arc shields must be in correct position. A misaligned arc shield will seriously decrease the arc interrupting ability of the entire blowout structure and may interfere with the opening and closing of the contactor

CAMERON PACKERS

The Industry's No. 1 Choice for DUAL COMPLETIONS



Reference to Figures:

Type "G" Packer—(1) Valve Cage, (2) Valve Packer, (3) Flow Pipe, (4) Valve Seat, (5) Packers, (6) Packer Spacer, (7) Packer Retainer, (8) Mandrel, (9) Shear Pin, (10) Lower Sleeve, (11) Spring, (12) Seal Rings, (13) Drive Nipple, (14) Reducing Coupling.

Type "J" Packer—(1) Cross-Over Head, (2) Cross-Over Ports, (3) Upper Sand Production Ports, (4) Packers, (5) Packer Spacer, (6) Upper Sand Inlets, (7) Packing Rings, (8) Drive Nipple.

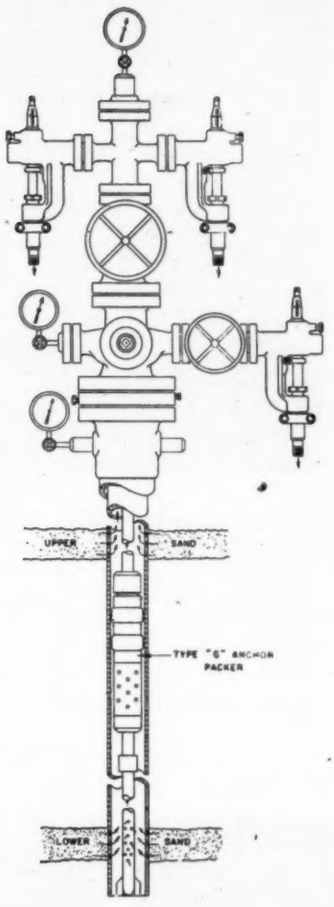


Figure 1

Figure 1 illustrates the use of a Cameron Type "G" Circulating Anchor Packer to separate producing zones in a normal dual completion.

Figure 2 illustrates the use of a Cameron Type "G" Circulating Anchor Packer in conjunction with a Type "J" Cross-over Packer to produce the upper sand through the tubing and the lower sand through the oil string.

Cameron surface control equipment assembled on Ram Type Tubing Control Heads, which is also widely used for dual completion work, is illustrated in the above drawings.

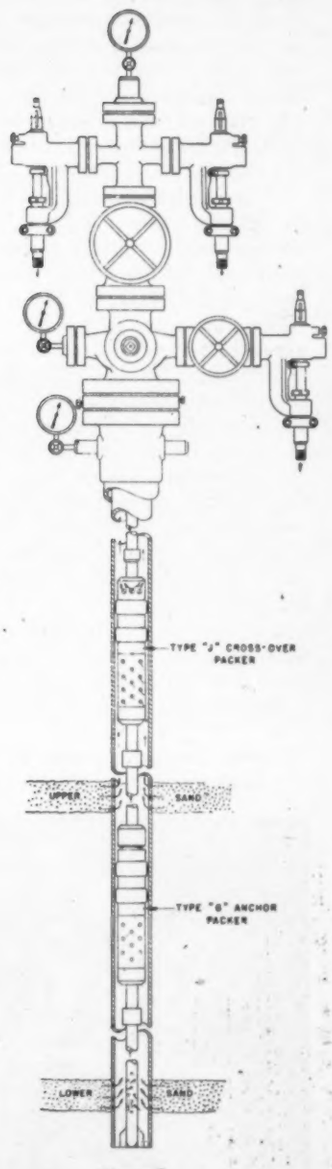


Figure 2

Obviously, the key to successful dual completions is a positive sealing packer to separate the producing zones. Cameron Type "G" Circulating Anchor Packers with patented SELF-FEEDING resilient sealing element equipped valve, assure a pressure-tight seal even though the seat may have been substantially cut during washing operations. They are set by simply lowering the tubing string until approximately one-half of the weight is on the packer and released by merely picking up on the tubing.

The Type "J" Cross-Over Packer is widely used, in conjunction with the Type "G" Packer, when it is desired to produce an upper sand through the tubing and a lower sand through the oil string, this being the reverse of normal dual completion operations.

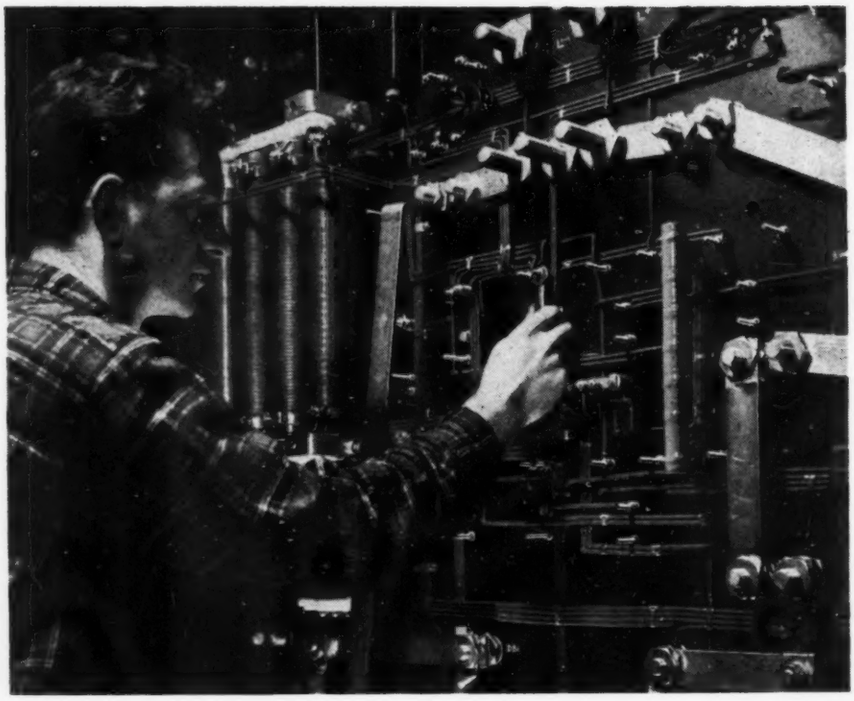
See your Composite Catalog for complete details, or descriptive literature will gladly be sent on request.

CAMERON IRON WORKS, INC.

711 MILBY ST., HOUSTON, TEXAS

Export 74 Trinity Place, New York N. Y. *California* The Howard Supply Co., Los Angeles
Rocky Mountain Mountain Sales & Service, Casper, Wyoming

Connections must be kept tight at all times. Loose connections are a frequent but very elusive cause of operating troubles



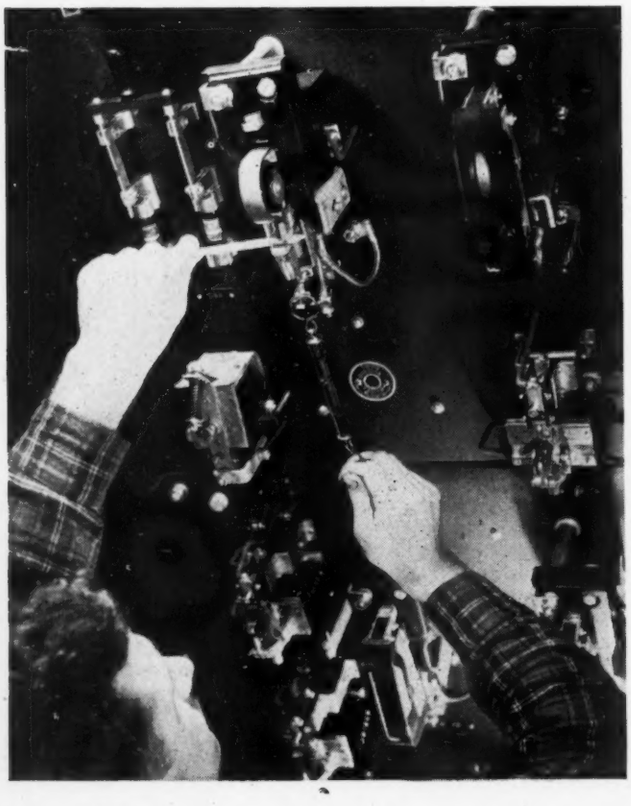
are made with no current through the contacts to observe how well they withstand the pounding, rolling, and sliding or scrubbing action that occurs every time the contacts close. Contactor designs often provide a rolling action of the contacts so that the circuit is initially closed and finally opened on the contact tips instead of on the smooth surfaces finally in contact when the contactor is completely closed.

When high currents that are difficult to interrupt are expected, powerful arc-rupturing magnetic forces are supplied to force the arc off the contacts and quickly break it. These arc-rupturing forces are set up by structures often called arc boxes or blow-out structures. When in operating position they completely surround the contacts and must always be in correct position to rupture the arcs effectively. They are easily removed for inspection or replacement of contacts. If they are not returned to proper position after inspection, the arc will not be properly broken and the contacts will be unneeessarily burned.

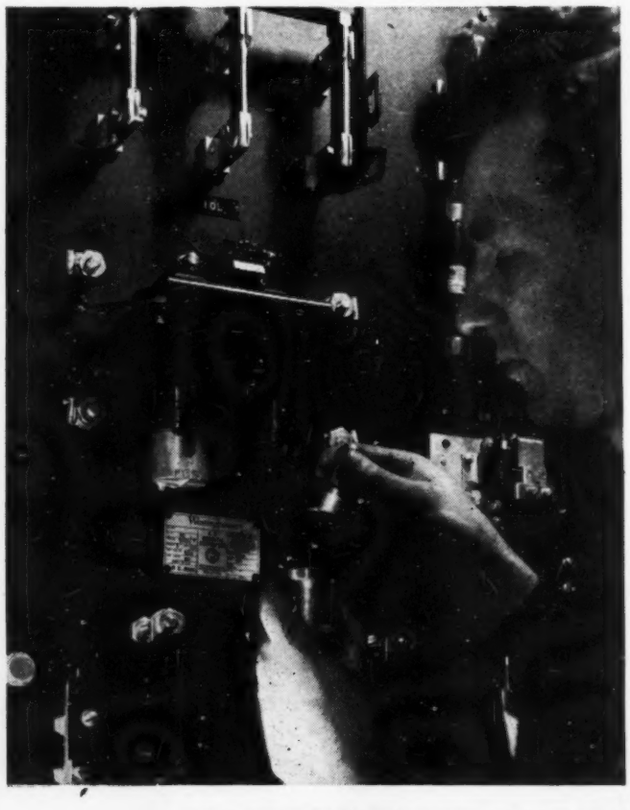
Contacts should be renewed when badly burned or pitted and when worn thin. They should be clean but need not be smooth. In fact, a clean contact with a roughened surface comparable to coarse sandpaper is a very satisfactory condition and provides as good, or better, contact surface than perfectly smooth surfaces. If a contact surface is pitted or burned and not worn thin it can be cleaned and used again.

The method of cleaning is important. Coarse and crude filing wastes material and is generally done without sufficient care to maintain the original contact shape. The contact surfaces then have high spots and point contacts that are apt to overheat. Instead, clean with sand-paper or a buffing wheel. A fine file is permissible if the

Contact pressures should be checked. Weak springs and overworn thin contacts reduce contact pressures



Weatherproof enclosures for control systems insure satisfactory service in outdoor installations



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contact shape is maintained. Emery paper should never be used as particles may adhere to the surface and cause unnecessary wear.

Silver contacts seldom require cleaning. They may look black and dirty because of the silver oxide but as the oxide is a conductor, cleaning is not often necessary.

When contacts are replaced, the surface against which they are bolted should be thoroughly cleaned. This is usually a current carrying joint and a clean contact bolted to a dirty surface cannot give best results. Both surfaces should be clean. Any traces of copper oxide should be removed.

The screws or bolts that hold contacts in place must be tight at all times. A loose contact surface offers high resistance and develops heat. This causes increased oxidation of the copper contacts. As copper oxide is not a good electrical conductor, this oxidation creates still more resistance and heat. This action is cumulative and eventually causes contacts to melt and deterioration of the entire contact assembly.

When contacts open and close, the rolling and rubbing action combined with the slight burning of a normal arc combine to keep the contacts bright and clean. If the contacts operate infrequently, the cleaning action does not occur and a covering of copper oxide develops. The heating-oxidation cycle may start and eventually overheating may develop even though the current or load is normal or less. For such conditions, silver contacts will probably give better service as silver oxide is a good conductor and heating does not develop. Silver contacts may also provide some relief in cases where a small overload condition is troublesome. They must, however, be used with some caution because they will not correct overheating caused by loose connections. As silver has a lower melting temperature than copper, silver contacts are more prone to become soft and "weld" or "freeze" together when subjected to high arcing temperatures.

Other special alloy materials are available that give reasonably good service under certain unusual or specific conditions. Contacts made of special materials should be used only on advice of the manufacturer of the device. Usually they are rated at lower current carrying capacities than similar contacts of copper or silver.

Contact pressure determines current carrying characteristics. The closed pressure of contacts is an important factor in their ability to carry current. A small contact with suitable contact pressure will carry more current than a larger one with little or no pressure. Renewal of thin contacts is required, as with wear they lose their contact pressure. It is also important to keep the contact springs in good condition. Replace them if they have been damaged or have lost temper through exposure to high arcing temperatures.

A monthly inspection of contacts for pressure, available life, surface condition, temperature, and tightness should suffice for normal conditions. For severe operating conditions a weekly inspection may be advisable.

Renew frayed shunts. Shunts are generally flexible bands of woven copper strands that carry current from the movable contacts to a stationary stud. If the shunt is unduly bent its strands break and cause additional loading of the remaining strands.

Shunts with broken strands should be renewed to prevent overheating. The terminal connections of the shunt should be tight. Shunt ends are frequently silver plated or covered with special finishes to insure a clean contact surface of good current carrying ability.

Coils should operate at rated voltage. After coils are wound they are treated with insulating varnish to improve their dielectric strength and make them a solid mass. This makes the coil less susceptible to mechanical injury, eliminates air pockets within the winding, and enables the coil to radiate heat more readily than an untreated coil.

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And when victory is won the Guiberson "G" will carry forward the precision production of products wrought from the metals of the world

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ESTABLISHED 1919

THE GUIBERSON CORPORATION

GUIBERSON DIESEL ENGINE COMPANY

Dallas, Texas

Alternating-current coils are designed to withstand 10 per cent over-voltage and operate the devices at 85 per cent of normal voltage. Direct-current coils will withstand 10 per cent over-voltage and operate devices at 80 per cent of normal voltage.

Over-voltage operates a contactor or relay with more mechanical force and tends to shorten the mechanical life if allowed to prevail. Over-voltage also shortens the life of a coil because it operates at a higher temperature. Low voltage will cause sluggish action. The contact tips may touch but may not be forced completely closed against the contact spring pressure. Under such conditions the contact tips will most certainly overheat and probably "weld" together. Contacts must always close completely.

On a-c. service, the coil current is much higher while the contactor is closing than after it is closed. A-c. coils are not designed to stand the open gap or closing current continuously. If any mechanical interference prevents complete closure of the magnetic air gap of an a-c. device, its coil will soon be overheated.

Open circuited coils are easily detected because they cannot operate the device. A voltmeter connected across the coil terminal of an open coil would indicate the full voltage of the control circuit. A coil with some turns short circuited might operate, but it would soon overheat and burn out. As most designs permit quick replacement of parts, a questionable coil could be replaced by a new one and the operation of the unit then checked for satisfactory performance.

Dead center opening reduces mechanical vibrations. When a magnetic contactor opens, the movable part strikes the stationary stop rather forcibly. There is a dead, or center of percussion point at which the effect of the blow is nullified. If the striking occurs at some other point the device is subjected to mechanical vibrations and strains that reduce its mechanical life. If the design of a contactor locates properly the armature stop with respect to the center of percussion point, undesirable shock and vibration of parts will be reduced and the mechanical life of the entire device will be increased. The effect of this feature is vividly illustrated by the sting of a baseball bat if the ball strikes near the end.

Dirt or rust may be cause of excessive noise. D-c contactors always operate quietly when closed. A-c. contactors may be noisy.

The laminated magnetic structure, necessary on a-c. designs, must be held tightly together by screws, rivets, or other means. If the laminations become loose the assembly will be noisy. Noise will also result if the movable and stationary pole pieces do not fit well together when the contactor is closed. Dirt or rust may prevent proper closure of these surfaces and cause objectionable noise. To prevent rust on these fitted surfaces during shipment some grease is applied. The excess grease should be removed when placed in service to eliminate a sticking effect when the surfaces are closed against each other.

The most important device in reducing noise of an a-c. device is the shading coil usually imbedded in a part of the laminated magnetic structure. This coil is often a single turn of wire or strap and if broken the noise will be most objectionable. If contactor is noisy, look first for a broken shading coil.

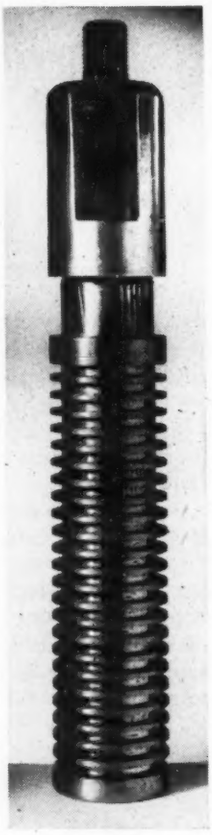
Oil-immersed and explosion tested control. When application is to be made in explosive or corrosive atmospheres, the entire contactor equipment is completely immersed in oil. The oil should always be maintained at proper level and the oil should be kept clean. Arc quenching causes oil deterioration due to the formation of carbon particles and sludge. A monthly inspection of oil immersed equipment is adequate unless service is exceptionately severe, causing the oil to deteriorate rapidly.

"Explosion tested" starters are intended for use in explosive atmospheres

Martin Plungers Mean Maximum Performance!

While our Armed Forces are doing a lot of tough fighting on many battlefields throughout a war-torn world, Martin Plungers are pumping a lot of tough wells in many areas.

But Martin Plungers are good for innumerable "missions" into the deep recesses of the nation's oil fields. Fortunately, Martin Plungers have always been designed and built so that thousands of them that were put in service before Pearl Harbor are still serving without "absenteeism," "furloughs" or "hospitalization." The reason is the exclusive Martin One-Piece Body and Split Rubber-Fabric Rings—they do the trick.



Martin Plunger Body After Four Years Use.

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See Composite Catalog

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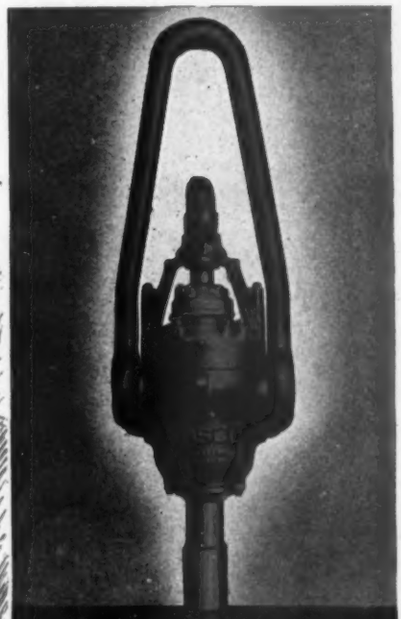
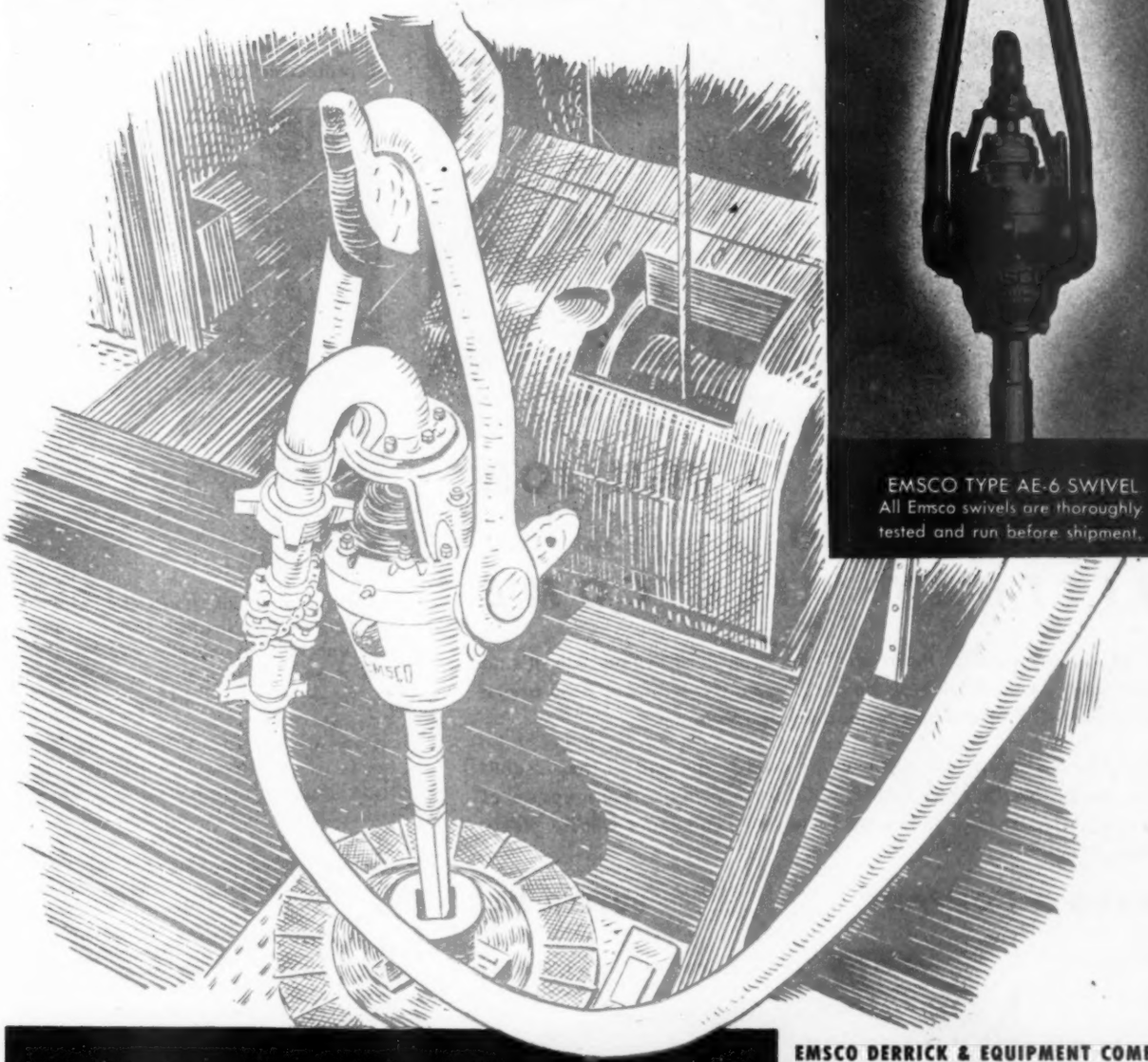
There's an EMSCO SWIVEL for any drilling speed or depth

Low production costs depend on using exactly the right equipment at the right time for the job at hand. Wasted capacity—and money—result from using equipment with a higher rating than necessary. Inadequate capacity is even worse, resulting in strain and excessive wear on the whole drilling assembly. Emsco offers a wide variety of sizes and types of swivels, engineered to meet any conditions you may find in your drilling operations.

Emsco swivels are designed to give satisfactory service under average normal operating conditions with plus values built in to absorb the shock loads caused by bouncing and jarring, and other abuses. They are especially designed so that all bearings are rigidly supported by the housing, thus eliminating distortion under heavy loads. Wash pipe replacement is minimized by the use of special heat treated materials and surface grinding to give efficient and long life. Packing is of the self-sealing type, automatically conforming to varying pressures, and eliminates the necessity of adjusting wash pipe glands with wrenches. A sealed mud throw-out bonnet of the tongue and groove type is especially provided in the design to prevent the entrance of mud, water or other foreign substances to the swivel body. These are only a few of the reasons why Emsco swivels appeal to drilling crews. They're worth your investigation.



EMSCO TYPE AE-6 SWIVEL
All Emsco swivels are thoroughly tested and run before shipment.



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BUT

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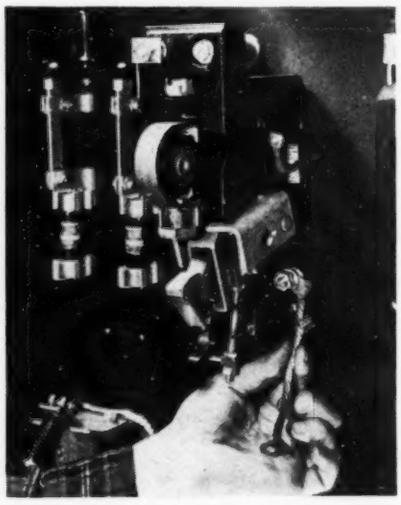
Materials are scarce, the old must be used to the end of their usefulness. As always, SPANG CABLE TOOLS are giving a full measure of service. After the war they'll be better still, and there will be plenty of them too.

SPANG & COMPANY **BUTLER, PA.**

without the use of oil. These starters are built to specifications of the Underwriters' Laboratories. The enclosing cases are built to withstand high pressures that occur within the case if internal explosions should occur, and to prevent flames escaping into the external explosive atmosphere. The cover should never be loosened or removed without first disconnecting the contactor from the power supply by means of the knife switch or breaker properly provided for the purpose. If dismantled, the parts of an explosion tested starter must be carefully assembled to be sure that all bolts, nuts, and joints are tight. Operation in the explosive area, unless properly and completely assembled, is not permitted.

As many parts of contactors and relays are made of steel and subject to rust, these parts are always covered with a protective coating such as zinc or



Broken strands of shunts cause the remaining good strands to carry more current and eventually overload the shunt and cause it to overheat. Damaged shunts should be removed

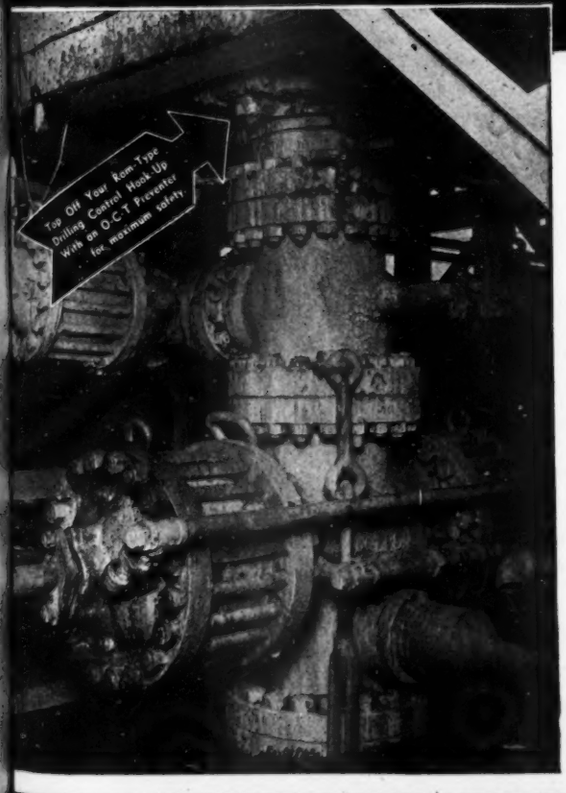
cadmium plating. Copper and brass parts are often treated with a light finish to protect against oxidation and for sake of appearance. Steel cabinets are painted; small sizes often have baked finishes. Galvanized sheet is often used to give added assurance against corrosion.

Connections must be tight and clean. Loose connections are a frequent cause of trouble. They result in overheated parts that eventually must be replaced. Connections once tight will not always remain tight. Periodic inspection is necessary, as changes in temperature, vibration, and carelessness all may cause loosened connections. Connections should always be clean and tight.

Resistors used in armature or field control circuits frequently fail because

Insure Against Blowouts

WITH AN O-C-T BLOWOUT PREVENTER



Operations in wildcat or proven high pressure areas should have the added protection afforded by O-C-T Blowout Preventers. Installed above ram type drilling control units, O-C-T Preventers fill three vital needs: (1) They provide a dependable secondary seal against destructive well pressures. Should the ram type seal fail for any reason, the pack-off in the O-C-T Preventer is capable of sealing off against highest well pressures. (2) While rotating and working pipe under pressure to prevent sticking, the ram type preventer may be opened to relieve the ram packers of wear and tear. The O-C-T pack-off is relatively inexpensive and more easily replaced. (3) When equipped with a stripper type pack-off, drill pipe, casing or tubing may be run in or out of the hole under pressure.

The small cost of an O-C-T Blowout Preventer is insignificant compared with the cost of a blowout. Complete specifications on all models are carried in your Composite Catalog, or a copy of the new O-C-T catalog will be sent on request.

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of excessive temperatures. Overheating may be caused by overloading, by more continuous service than was anticipated in the design, or by improper ventilation. Loose connections often cause local heating with eventual burned connectors. Grid or cast types sometimes break in handling or with frequent and sudden overheating and cooling. Resistors should always be kept clean, their assembly and connections should be kept tight, and proper ventilation should be maintained.

Keep apparatus clean and dry. Moisture, dirt, and dust are constant sources of trouble as they reduce insulation values of insulated wires and creepage spaces. They constitute a leakage path across which breakdowns occur between points of different potentials that would never occur across clean and dry surfaces. Routine maintenance should include removal of dirt and dust by blowing with dry compressed air, wiping or washing with suitable cleansing fluid. Compressed air under too much pressure may drive metallic dust and dirt into insulation or lodge particles between moving parts of contactors and relays.

Moisture may occur from condensation, humid atmospheres, spray, overhead dripping, or other conditions. Heaters are sometimes placed in enclosures to keep the interiors warm relative to the exterior and thereby prevent sweating. They are generally arranged to be automatically effective when the equipment is idle because the normal heat of resistors and coils is sufficient while in operation. Enclosures may be dripproof, watertight, dusttight, or explosionproof. In any case doors or covers should be kept securely closed or fitted, and any damaged gaskets replaced.

Moisture in conduits is a frequent source of grounds or short circuits. Grounds cause false circuits that may cause unexpected starts, prevent stopping by normal means, eliminate overload protection, and cause erratic operation. Any measures to prevent moisture in conduits are good insurance against trouble. When serious grounds develop they are eliminated by cleaning the conduit and installing new wiring. The insulation resistance should be checked regularly so that the presence of grounds can be detected and if possible eliminated before trouble occurs.

All wiring should be kept in good condition. Vibration will cause broken wires. Oil, moisture, dirt, grease, and excessive heat cause insulation breakdowns. Chafing or rubbing against unprotected edges soon wears away all insulation at that point. Exterior wiring with weatherproof insulation should in some cases be painted periodically with an asphalt base paint. Temporary wiring is hazardous. Nuts and lock nuts should be tight. Defective wiring is an outstanding cause of electrical trouble and fires. Regular inspection is necessary.

High temperature is a sure sign of trouble; however, one must be sure that the temperature is excessive. To touch a cabinet or coil or motor and decide it is too hot is not a safe procedure because safe operating temperatures are often higher than one can comfortably feel with the hand. The best procedure is to know what temperature is considered safe and then actually measure it.

Here are the high points that should be checked to keep motor starters in good operating condition. They must be free of oil, dirt, and moisture. No oil should be used on contacts or bearings of contactors and relays. Connections should be tight and wiring should be safe. Movable parts of contactors and relays must move freely and without friction. Contacts should be clean and tight with correct pressure and not worn too thin. Arc-rupturing devices must be in operating position.

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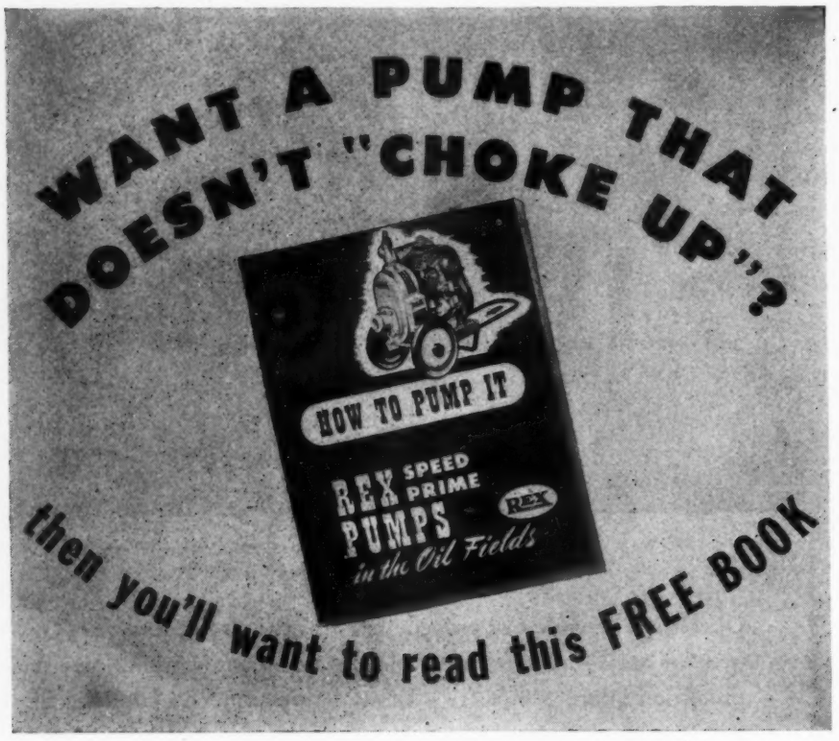
WANT A PUMP THAT DOESN'T "CHOKE UP"?
HOW TO PUMP IT
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REX
then you'll want to read this FREE BOOK

This cutaway view shows the famous Rex "free-flow" water passage. Arrows show the course of water through pump.

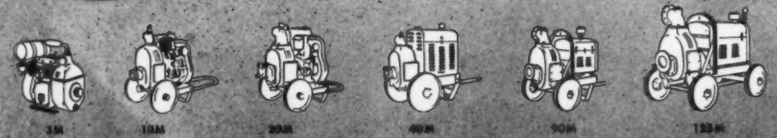
HEAVY oil- and cutting-filled drilling mud won't "choke up" and clog Rex Pumps. Their "free-flow" intake passage assures an unobstructed flow of liquid through the pump . . . permits handling of solids up to ¼ the size of the intake. Liquids rush in and out of the pump faster, and lack of obstructions means more efficient pumping performance.

On Rex Pumps, the suction valve works properly without adjustment or pampering. And it's faced with oil-resisting Neoprene...for long trouble-free service.

For complete information on Rex Pumps and other exclusive advantages such as the "Air Peeler" that permits Rex Pumps to operate even when the suction line is leaking air, send for your free copy of the informative folder, Bulletin No. 434. Chain Belt Company, 1719 West Bruce Street, Milwaukee 4, Wis.

REX

OIL FIELD PUMPS



CHAIN BELT COMPANY OF MILWAUKEE

"Well Digger"

THAT MADE GOOD!

The HUNT

WELDED-IN BLADE BIT

It's the oil country's No. 1 Hole-maker. Has cast alloy steel body, heat-treated; drop forged steel blades, heat-treated. Quickly replaced when worn. Fluid courses lined with special alloy bushing. Made in 2-way and 3-way types.

Hunt makes a bit to meet every drilling requirement. Full details in your Composite Catalog, or Hunt Catalog.

"A Business Built on Service"

HUNT TOOL COMPANY

FIELD SHOPS:
Houston, Bay City, Corpus Christi, Jennings, Shreveport, Harvey

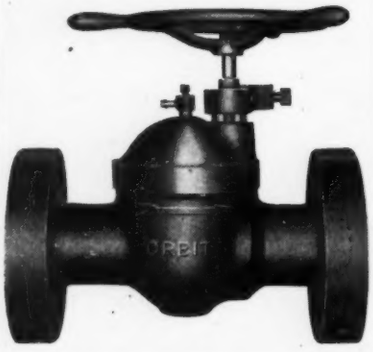
EXPORT SALES:
W-K-M Company, Inc.
74 Trinity Place, New York City

HUNT TOOL COMPANY

HOUSTON, TEXAS, U. S. A.

ORBIT VALVES

The Valves that can "Take It"



ORBIT MASTER VALVE

The Orbit Master Valve is quick opening—has easy operation and a positive shutoff. A welded bonnet valve—insurance against possible gasket leaks.

•

YOUR ORBIT VALVES

will last for the duration. Meanwhile, if you have any questions regarding their care or maintenance, write us.

•

OIL WELL IMPROVEMENTS CO.

Since 1912

TULSA, OKLAHOMA

Running Tour

WITH MEN IN THE INDUSTRY

STANLEY ASP, on leave of absence for Filtrol Corporation of Los Angeles, California, and Jackson, Mississippi, has been advanced from a captain to a major in the Engineer Base Headquarters Company. Major Asp is now serving in the European theater.

C. W. COOPER, field gauger at McCamey, Texas, for Shell Pipe Line Corporation, has been presented with the president's medal of the National Safety Council for saving the life of W. G. COLLUM, a Gulf Oil Corporation lease pumper. H. H. Anderson, vice president of Shell, made the presentation.

COL. C. S. ADAMS, of Palm Beach, Florida, has been named head of a petroleum section in the U. S. Middle East headquarters at Cairo, Egypt, that will act as a coordinating agency for the commanding general between various oil organizations and the army. The section will also serve in an advisory capacity.

CARL V. BENZ has opened offices at 3217 Milam Street, Houston, Texas, as a consulting geochemist and petroleum engineer, specializing in soil analysis. Benz resigned from the George W. Strake interests, with which he had been associated for 11 years.

ARTHUR D. SMALL, who was engineer in charge of the Oklahoma Secondary Recovery Committee before entering the army in August, 1942, as a major, has been promoted to lieutenant colonel. He is engineer in charge of the petroleum division, Washington, D. C.

DELLOYD D. NASH, project engineer, Standard Oil Development Company, Linden, New Jersey, is now director of construction for District 1—the East Coast—of the Petroleum Administration for War. He succeeds Edward Kares.

DR. FREDERICK G. CLAPP, 64, internationally known geologist, died February 18 of spinal meningitis. He had recently returned from Turkey where he was oil advisor to the Turkish government and was in Chickasha, Oklahoma, to inspect some oil properties when he was stricken. A former instructor at Massachusetts Institute of Technology, Clapp distinguished himself in his field. He was at one time petroleum advisor to the Shah of Persia and had made studies of formations in Arabia, Afghanistan, Persia, and Canada.

CAPT. HILAND R. SMITH, APO 7383, c/o Postmaster, San Francisco, California, writes that he has arrived in Australia where he has an assignment in his profession. He said he was using *The Petroleum Engineer's* Continuous Tables in his work about which he was enthusiastic. He would like to hear from his friends in the industry.

CAPT. VAN D. BENNETT, Hdqts. SOS Engr. Sec. Pet. Bn., APO 750, New York City, New York, is getting a taste of contrast in climate. After service in Alaska he recently crossed the Atlantic by air. He wrote for a subscription to *The Petroleum Engineer*, saying he was in a phase of the oil business and wanted to keep up with developments.

PAUL D. TORREY, formerly consulting engineer at Houston, Texas, has recently recovered from a long siege of illness in Seattle, Washington, where he has been stationed. He is doing some professional work in the Northwest for the U. S. Navy.

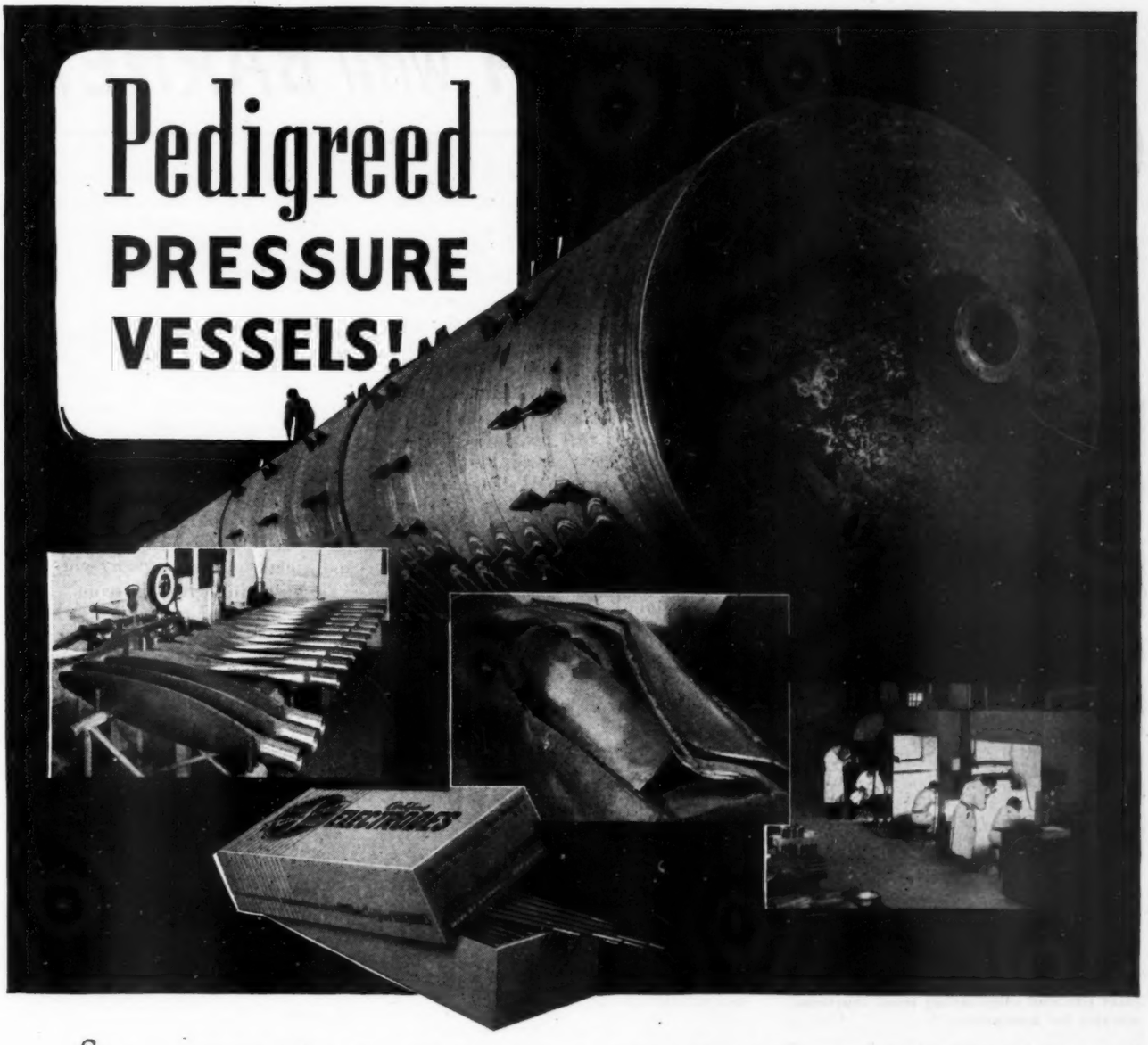
E. B. IRVAN, sales representative of Spang and Company, Butler, Pennsylvania, passed away at his home February 20. During his 15 years with the firm Irvan represented Spang in Oklahoma, Kansas, and Texas. For the last 8 years he had the Michigan territory with headquarters in Mt. Pleasant.

ARTHUR R. WEIS, president of Pacific Pumps Works, Huntington Park, California, has been in Tulsa, Oklahoma, where he handled business for his company in the Mid-Continent area.

M. J. BONHAM has been named district land man for the new Tyler, Texas, office of the Continental Oil Company. W. A. ROUNDS is the engineer and assistant land superintendent and G. N. ELY is district geologist. All three are veteran Conoco men.

DWIGHT R. MEANS, who has been associated with Columbia Chemical Division of the Pittsburgh Plate Glass Company for 21 years, has been named assistant to the president. Means has served as research director, assistant superintendent, and technical director.

Pedigreed PRESSURE VESSELS!



Some people seem to think it is easy to make a pressure vessel. We don't!

Some people seem to think a pressure vessel can be designed and built from the data contained in the standard engineering handbooks.

We don't! We never have.

We learned how to make pressure vessels by a long and difficult process of experiment, testing, and experience.

In our plant, one of the world's greatest steel-working plants, we have learned much about steel. Therefore, the steel that goes into A. O. Smith Pressure Vessels is produced to A. O. Smith specifications.

In our plant, one of the world's greatest welding plants, we have learned much about welding. Therefore, we developed our own welding processes—even to the point of making our own electrodes.

And step by step we tested! In our own metallurgical and physical testing laboratories we proved each minute point in the process. We made pressure vessels for ourselves that we might *test them to destruction!*

Then and only then did we know! Thus we established the pedigree by which you can judge pressure vessel value and buy with assurance.

BUY MORE WAR BONDS!

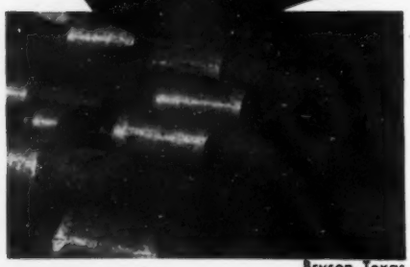
ELECTRIC-WELDED PRESSURE VESSEL

A. O. SMITH Corporation

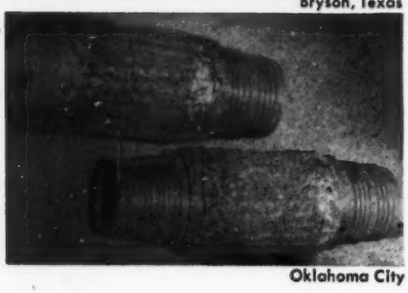
MILWAUKEE 1 • WISCONSIN

Offices at: NEW YORK • PITTSBURGH • CHICAGO • TULSA • HOUSTON • LOS ANGELES • SEATTLE

STOODY HARD-FACING METHOD KEEPS TOOL JOINTS WORKING at a Saving!



Bryson, Texas



Oklahoma City

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Protected joints are outlasting unprotected joints two-to-one—and more! Operators are reclaiming old joints . . . greatly increasing new joint life . . . maintaining full joint efficiency.

The Stoody hard-facing application is simple. Use either Electric Tube Borium or Coated Stoody Self-Hardening—and apply directly over the tool joint or to a recess machined in the joint, as desired. The Stoody representative in your territory will gladly supply detailed information on the Stoody method of hard-facing tool joints in your drilling string. Or write for free copy of the Stoody Engineering Bulletin which gives details.

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1142 W. SLAUSON, WHITTIER, CALIF.

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Stop wear . . . Eliminate Repair

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Accused: I was hungry.

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But two other reasons were betta.

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City Slicker: What I want to know, is she tender?

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For such water shut-off applications, operators have found the Baker Model "K" Cement Retainer to be the most effective and economical tool to use.

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Putting in 10 barrels of water ahead of the cement, the formation took the water at 2100 lbs. per sq. inch. A batch of 75 sax of cement was then pumped down and 35 sax squeezed out with a final pressure of 3500 lbs., the excess cement being flushed out with reversed circulation. After drilling out the cement and completing the well again, it came in making 643 barrels of 29° A.P.I. oil with a gas/oil ratio of 350 to 1.

ARMY E NAVY

Awarded to Los Angeles Plant—1943

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Central Division Office and Factory:
6023 Navigation Blvd., Box 3048, Houston, Texas
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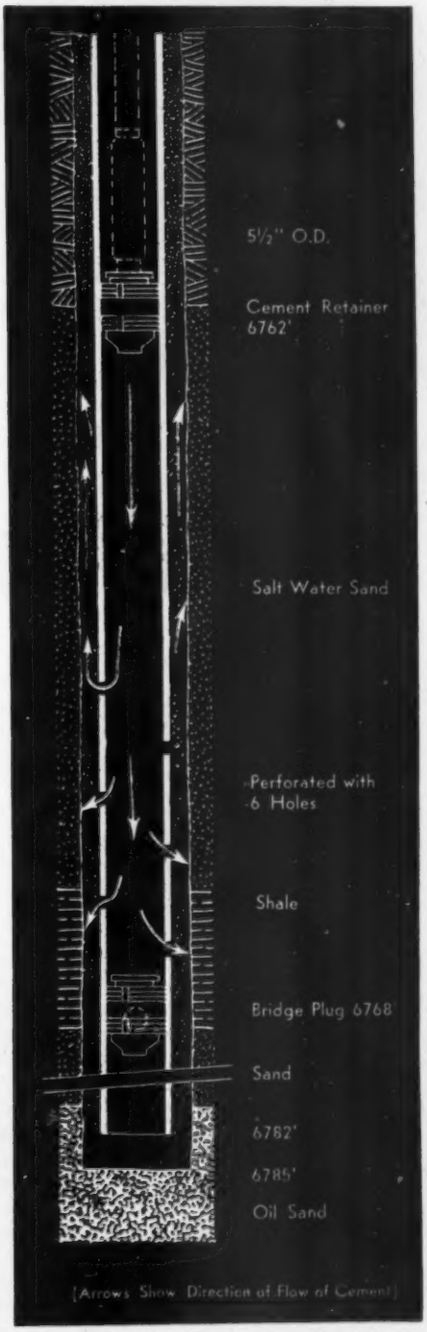

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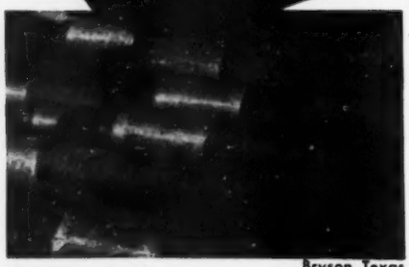

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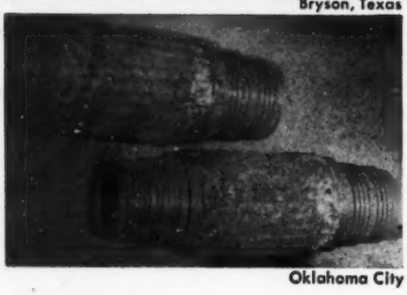

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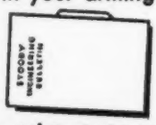

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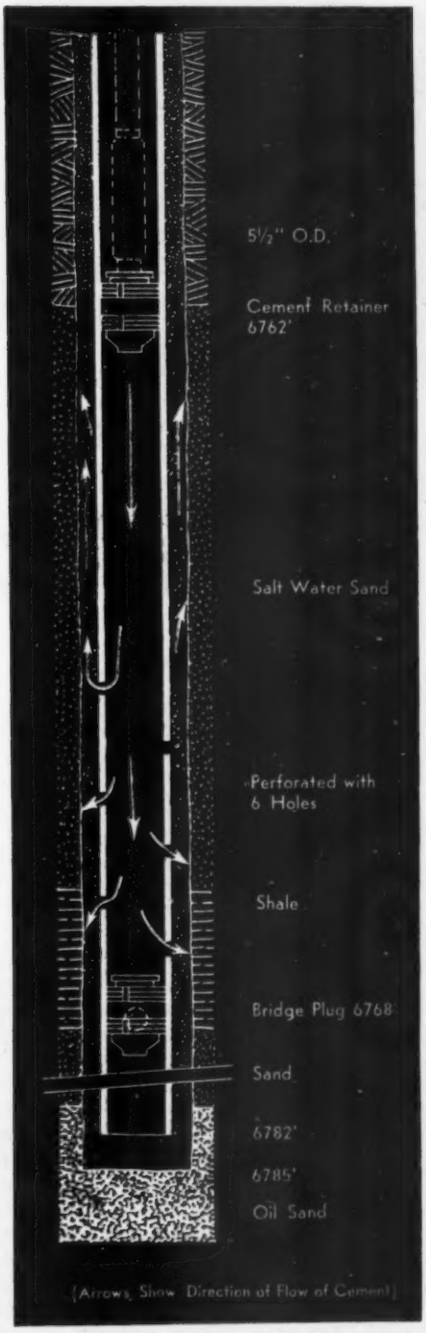

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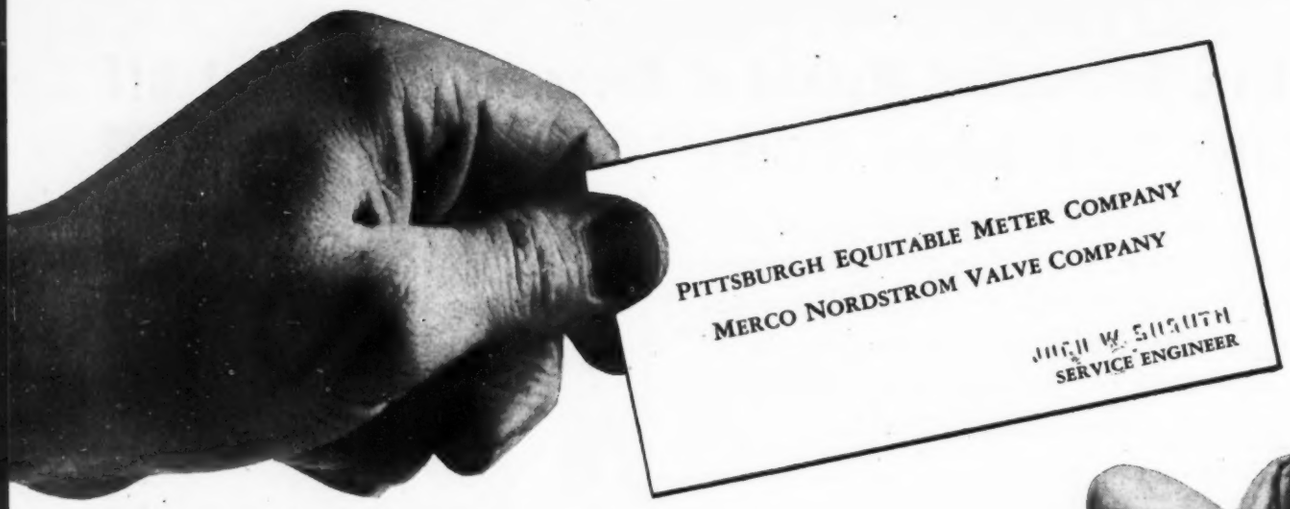


LET'S ALL GIVE THIS MAN

a Great Big Hand

Traveling men are today probably operating under heavier handicaps than any other group. With gas rationing, crowded trains and busses (more frequently than not running on late schedules), and hotel accommodations virtually unobtainable in many centers, these "ambassadors of the brief case" deserve a world of credit for carrying on in the face of many obstacles. They neither ask for or receive any special favors, but plug away bringing to their customers about the only thing many have to sell today—service.

Of course, a great number of our products are necessary and vital to the successful pursuit of the war. Other lines have been discontinued entirely for the duration. Selling, as such, is virtually a thing of the past, but engineering and technical assistance, particularly in maintenance and installation work, is very important. We have retained our entire staff, which has been carefully built over the years, to bring those in the field the maximum knowledge and experience in measurement and control.

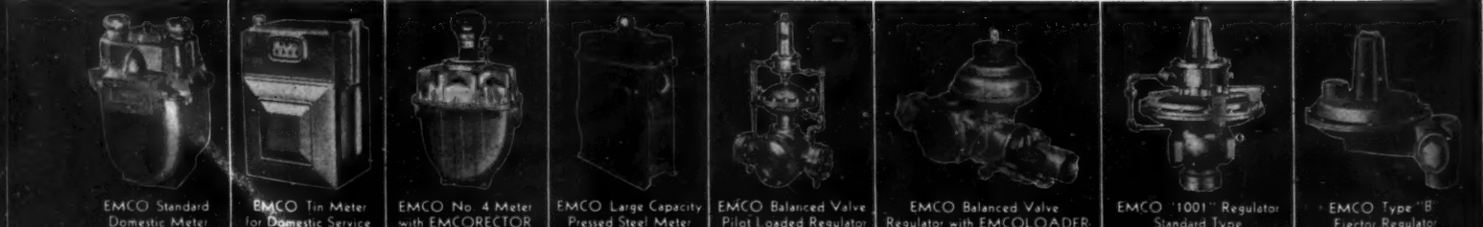
Some of our service engineers have been temporarily transferred to other jobs in our organization, such as, expediting, engineering and manufacturing, where special talents could be best utilized in producing war goods. They have willingly sacrificed their personal desires in the interests of their Country. When Victory is won, they will again be assigned to their territories to call on old friends whose contacts they sorely miss. These men are now having a hand in writing the future. They deserve a big hand from all who know or have worked with them.

PITTSBURGH EQUITABLE METER CO.

Atlanta **MERCO NORDSTROM VALVE CO.** Boston
Brooklyn Main Offices, PITTSBURGH, PA. Buffalo
Chicago Columbia Houston Kansas City
Los Angeles New York Pittsburgh
San Francisco Seattle Tulsa

National Meter Division, Brooklyn, N. Y.

EMCO METERS AND REGULATORS



EMCO Standard Domestic Meter | EMCO Tin Meter for Domestic Service | EMCO No. 4 Meter with EMCORECTOR | EMCO Large Capacity Pressed Steel Meter | EMCO Balanced Valve Pilot Loaded Regulator | EMCO Balanced Valve Regulator with EMCOLOADER | EMCO "1001" Regulator Standard Type | EMCO Type "B" Ejector Regulator

THE *Petroleum* Engineer's CONTINUOUS TABLES

A DAILY REFERENCE FOR OPERATING MEN

INSTALLMENT NO. 81

A VALUABLE and regular feature of *The Petroleum Engineer,* the Continuous Tables, now in their seventh year of publication, were designed to save time and effort for the technician and the practical field or plant worker. The tables have proved one of the most popular and helpful departments of *The Petroleum Engineer.* Data are presented in the simplest form available with many types of information included that are best presented by curves or nomographs when three or more variables must be considered simultaneously.

The Continuous Tables have developed as a result of suggestions for new tables, direct contributions, and improvements to existing tables by members of the petroleum and related industries, including manufacturing concerns, who are continually searching for practical information reduced by computation to tabular form readily applicable to the problems daily confronting them that might otherwise necessitate a more or less tedious calculation. These contributions and suggestions from the industry have resulted in a valuable exchange of information and data contributing to the progress of the industry as a whole.

This index will be revised monthly. The index for installments 1-12, inclusive, will be found in the May, 1938, issue; 13-24, inclusive, in the June, 1939, issue; 25-36, inclusive, in the June, 1940, issue; 37-48, inclusive, in the June, 1941, issue; 48-60, inclusive, in the June, 1942, issue; 61-72, inclusive, in the June, 1943, issue, and 73-79, inclusive, in the January, 1944, issue.

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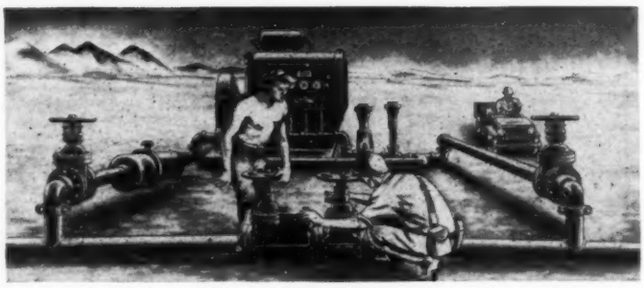
HANLON-WATERS
Automatic
Control Equipment



Hanlon-Waters Portable Pipe Line in use by the Armed Forces.

IS SERVING ON PIPE LINES ON THE

Fighting AND *Working* FRONTS

H-W Control Equipment on portable pipe line pumping units are in action aiding materially in keeping airplanes, tanks and other motorized equipment operating in battle zones around the world.

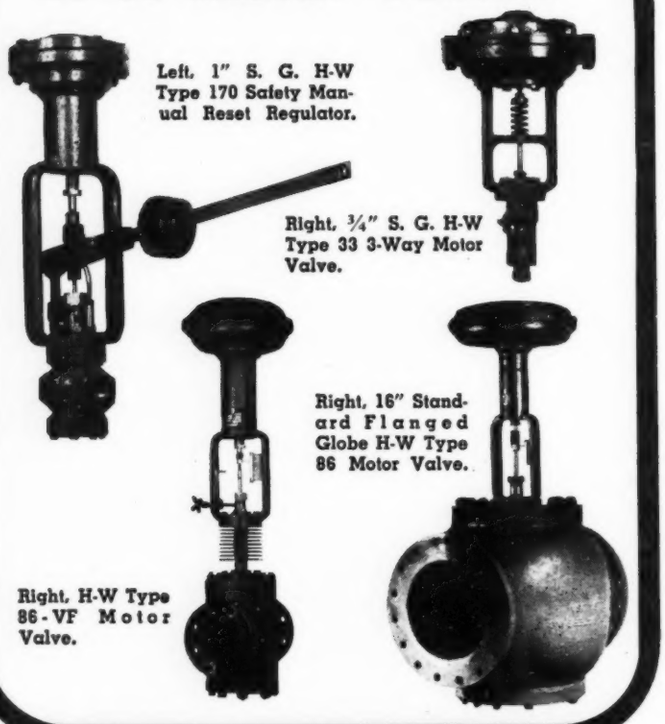
Here at home and in Industry of many lands, H-W Equipment, long the Standard for Performance in the Refining, Chemical, Synthetic, Gasoline, Recycling and Power Industries is your assurance of dependable, trouble-free service.

There are HANLON-WATERS Controls to meet every requirement, either standard or special designed, and for plants using highly corrosive liquids, special equipment is available. Informaton on the H-W Equipment to meet YOUR Control Requirements will be supplied promptly.

See 1942 Issue
REFINERY CATALOG
Pages 275-277

Information on all HANLON-WATERS Equipment is available at representative nearest you.

H-W Motor Valves



Left, 1" S. G. H-W Type 170 Safety Manual Reset Regulator.

Right, ¾" S. G. H-W Type 33 3-Way Motor Valve.

Right, 16" Standard Flanged Globe H-W Type 86 Motor Valve.

Right, H-W Type 86-VF Motor Valve.

Ask The Men Who USE Them!

STANDARD FOR *Performance*

ARMY E NAVY

HANLON-WATERS INC. H-W

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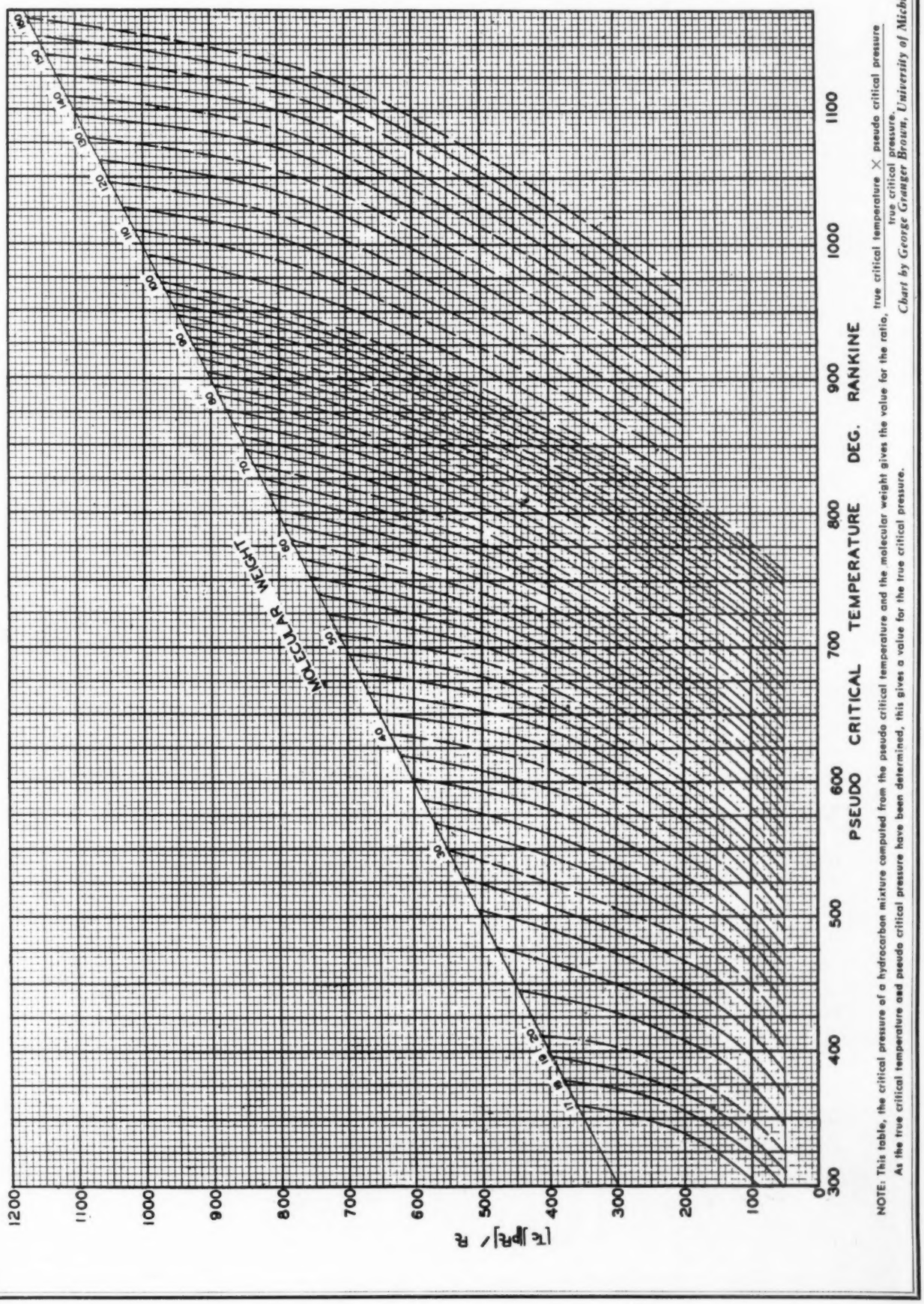
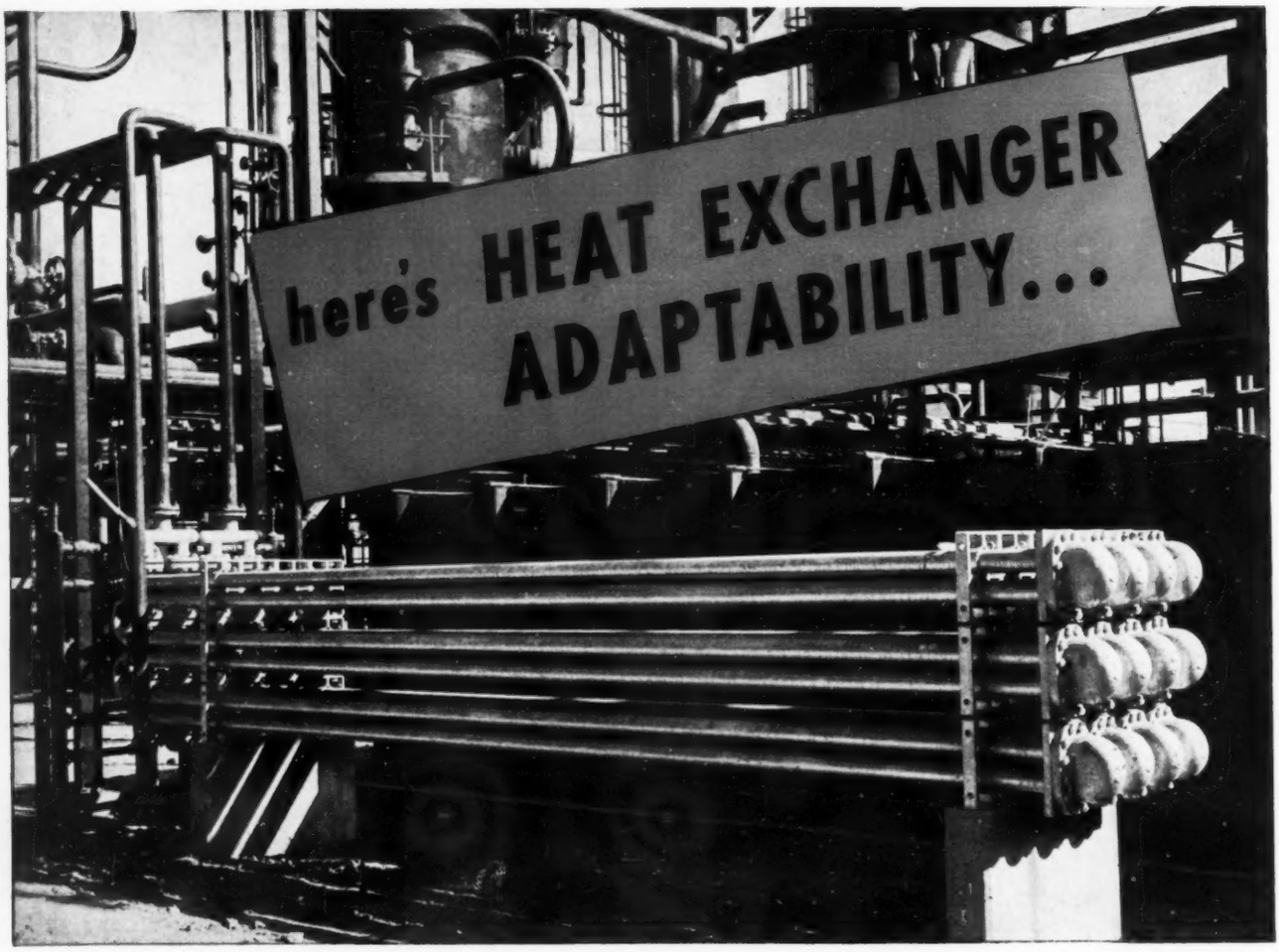
THE CRITICAL PRESSURE OF A HYDROCARBON MIXTURE



NOTE: This table, the critical pressure of a hydrocarbon mixture computed from the pseudo critical temperature and the molecular weight gives the value for the ratio, $\frac{\text{true critical temperature}}{\text{true critical pressure}} \times$ pseudo critical pressure. At the true critical temperature and pseudo critical pressure have been determined, this gives a value for the true critical pressure.

Chart by George Granger Brown, University of Michigan



5 DIFFERENT SERVICES in 18 months *without modification*

We know of one group of TWIN G-FIN SECTIONS, similar to these illustrated, that was used for 5 different heat transfer services in 5 different locations within 18 months, by merely modifying the grouping of sections.

These services were as follows:

1. Heating naphthene solution charge with steam.
2. Cooling lubricating oil with water.
3. Heat exchange between naphthene solution and solvent charge.
4. Preheating naphtha with steam.
5. Precooling solvent with water.

These standard, interchangeable units . . . over 40,000 of which are in use . . . have heat transfer elements with 6 to 8 times the surface of bare pipes . . . are easy to install . . . require no heavy rigging . . . are easy to clean and service . . . and their wide adaptability gives these units 100% salvage value.

THREE STARS—for continued excellence in war production—now mark the GRISCOM-RUSSELL "E" award

THE GRISCOM-RUSSELL CO. • 285 MADISON AVENUE, NEW YORK 17, N. Y.

GRISCOM-RUSSELL
TWIN G-FIN SECTION
The Universal Heat Exchanger

PHYSICAL CONSTANTS OF HYDROCARBONS

Hydrocarbon	Specific gravity 20/4 °C.	M.P. °C.	B.P. °C.	Index of refraction n_D^{20}	Viscosity Abs. Poises	Spec. heat	Heat of vaporization Cal/G.	Heat of combustion K-Cal/mol.	Aniline point °C.	Coeff. of expansion °C.	Critical constants P Atm.	Critical constants T °C.	Critical constants D	Vapor pressure °C.	Vapor pressure mm.	Octane number Actual	Octane number Blending	Surface tension Flash °C.
$C_{10}H_{22}$ Decane	$\frac{4.907}{0.72993}$ air	—29.7	174.0	1.4114	0.0090^{20} 0.0060^{150}	0.523^{25}	62.4	1619.4p	77.5	0.00106^{0-50}	21.2	346.3	0.230	90 130 165	50 200 600	—53r	—32r	23.9 46.1
2–Methylnonane (Isodecane)	0.72805	—74.3	166.8	1.4099		0.5263^{25}	61.0	1617.2p	80.3 cst					70 130	40 300	—16m		
3–Methylnonane	0.7335	—84.6	167.8	1.4125		0.5190^{25}	61.0	1615.1	78.2 cst							—5m		
4–Methylnonane	0.73234	—98.4	165.7	1.4123		0.5331^{25}		1615.1	78.3 cst							—20m		
5–Methylnonane	0.73255	—86.4	165.1	1.4122		0.5282^{52}		1617.7p	77.9 cst							8.0m		
2, 2–Dimethyloctane	0.7233*		155.3*	1.4084*				1615.1	81.0							59.0m		
2, 3–Dimethyloctane	0.7383*		164.3*	1.4157*				1615.1	75.0							35.0m		
2, 4–Dimethyloctane	$0.7259^{20/20}$		152.5	1.4090				1615.1	80.0							41.0m		21.79
2, 5–Dimethyloctane	0.7264*		158.4*	1.4096*				1615.1	77.0							44.0m		
2, 6–Dimethyloctane	0.7291		158.5	1.4107				1615.1	78.0					113.5 136.0	200 400	39.0m		
2, 7–Dimethyloctane (Diisoamyl)	0.7247	—52.6	160.0	1.4092	0.0082^{20} 0.0057^{50}	0.507^{22}		1611.2	78.0	0.00106^{15}	21.2	330.0		—2.2 10.3	0.43 1.10	34r	25r	22.22
3, 3–Dimethyloctane	0.7390		161.2	1.4165				1615.1	75.0							52.0m		
3, 4–Dimethyloctane	0.7447*		165.0*	1.4190*				1615.1	73.0							39.0m		
3, 6–Dimethyloctane	0.730		160.8	1.4145				1615.1	76.0							52.0m		
4, 5–Dimethyloctane	0.7438*		164.1*	1.4184*				1615.1	74.0							68.0m		22.22

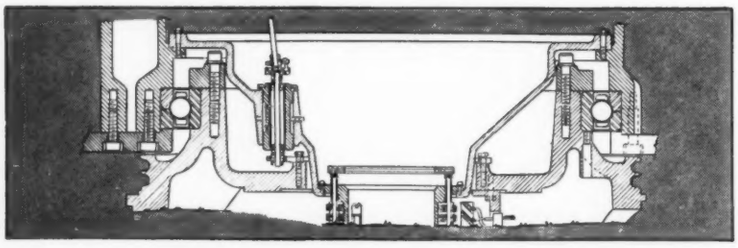
*Estimated.

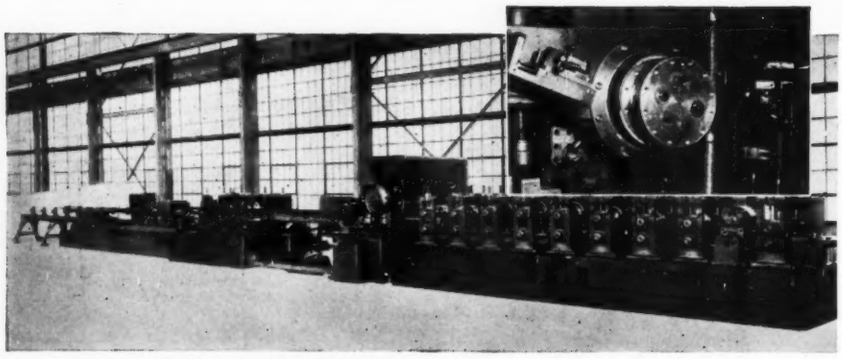
See table P 771.001. B for footnotes.

Table from "Physical Constants of the Principal Hydrocarbons," 4th edition, by courtesy of copyright owner, The Texas Company.

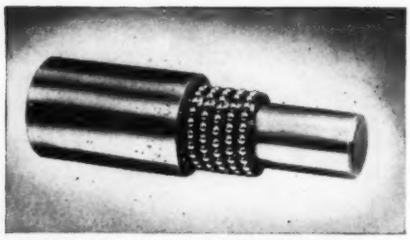
IN THE NEWS
WITH TORRINGTON BEARINGS

SIMULATING FLIGHT CONDITIONS, the Celestial Navigation Trainer, designed and built by Link Aviation Devices, Inc., provides operational flight crew training for navigators, bombardiers, radio operators and pilots. A fuselage which is a reproduction of a bomber nose is mounted on a universal joint and can duplicate the bank, pitch and turn of a plane under normal instrument flight. A large, 23-inch diameter ball radial bearing, supplied by Torrington's Bantam Bearings Division, helps support the fuselage, enables it to rotate with anti-friction ease and smoothness in response to the pilot's touch on controls. Photo above shows "terrain" as seen by navigator or bombardier.

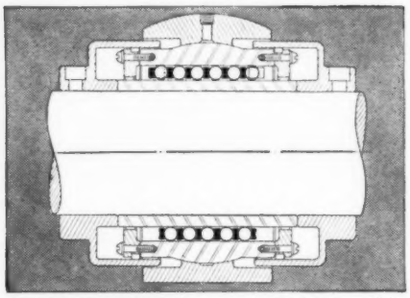




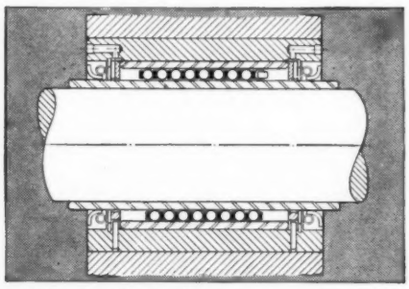
"FROM STRIP TO TUBING" describes the function of this 500 KVA Tube Welding Machine designed and built by The Yoder Company for feeding flat strip steel in, taking finished tubing out. Main electrode support shown in inset, rotates on a special 20" O.D. ball radial bearing supplied by Bantam for this "out-of-the-ordinary" application. Anti-friction bearings in every major type and in sizes up to 10 *feet* in O.D. are supplied by Torrington's Bantam Bearings Division. If you have a difficult or out-of-the-ordinary bearing job, TURN TO TORRINGTON for experienced assistance.



(1) NEW TYPE BALL RECIPROCATING BEARING that offers unusually high capacity is now available. Designed by engineers at the Bantam Bearings Division of The Torrington Company, this new anti-friction unit has a "spirally wound" retaining cage containing a full complement of balls over a long axial distance, and provides more than double the contact than heretofore available in a reciprocating bearing.



(2) NEW APPLICATIONS are expected from this new high capacity unit which offers the design engineer several advantages over the type formerly available. This X-section shows a typical mounting suggested for printing press inking rolls, designed to eliminate possibility of oil leakage.



(3) OTHER APPLICATIONS are expected to be found in engine governors, welding machine guides, doctor blades, coating machines, spool winders, buffers, polishers, etc. A number of methods of mounting are suitable, depending on existing design factors. A second suggested type is shown here.

A FULL RANGE OF NEEDLE BEARINGS to meet virtually any radial load requirement is included in the Torrington-Bantam line, as well as all major types of tapered roller, straight roller and ball bearings. Our engineers will be glad to work with you in selecting the right type for your requirements. Join the TURN TO TORRINGTON for your bearing needs.

ARMY ★★★ E ★★★ NAVY

TORRINGTON BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

THE TORRINGTON COMPANY · BANTAM BEARINGS DIVISION

SOUTH BEND 21, INDIANA

EQUIVALENT CRITICAL TEMPERATURE AND EQUIVALENT DENSITY AS A FUNCTION OF THE MOLECULAR WEIGHT

Note: The figure below is a plot of the equivalent critical temperature in degrees Rankine against molecular weight and the equivalent density in grams per cc. against molecular weight as indicated. Equivalent critical temperatures and equivalent density may be used for estimating critical properties of hydrocarbons as a function of the molecular weight. The equivalent critical temperature is the critical temperature of a normal paraffin hydrocarbon having the indicated molecular weight. Similarly, the equivalent density is the density of the normal paraffin hydrocarbon at standard conditions of the indicated molecular weight.

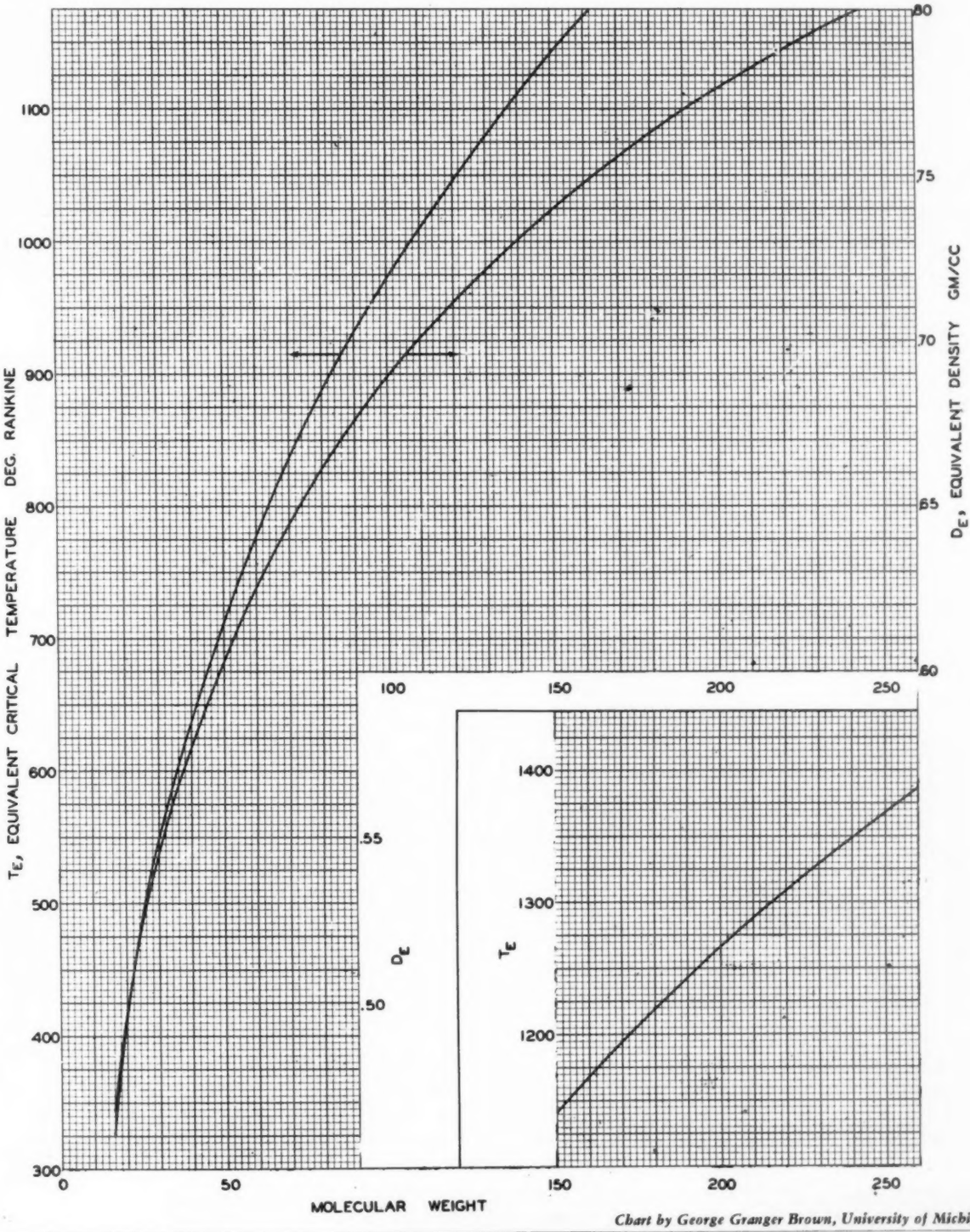


Chart by George Granger Brown, University of Michigan.

LAY·SET *Preformed* IS RELIEVED

Of course, this analogy is far-fetched but it is still true that the wires and strands of non-preformed wire rope are virtually locked in position—under constant stress—uncomfortable—cranky. Being so, non-preformed cannot work so well, nor long, as Hazard LAY-SET, which is preformed at the mill and entirely relieved of internal torsional stresses and strains. LAY-SET Preformed wire rope gives you greater dollar value, requires no seizing when cut; it resists kinking and whipping; it is easier to splice and safer to handle. And, invariably, it wears longer.

Ever since Pearl Harbor, and even before, Hazard LAY-SET Preformed has been saving time and money for the Government, the Armed Forces, and the taxpayer.

Specify Hazard LAY-SET Preformed for *all* its built-in advantages.

HAZARD WIRE ROPE DIVISION • Wilkes-Barre, Pa., Chicago, Pittsburgh, Fort Worth, Houston, Wichita, San Francisco, Denver, Los Angeles

Distributors in all important oil field centers

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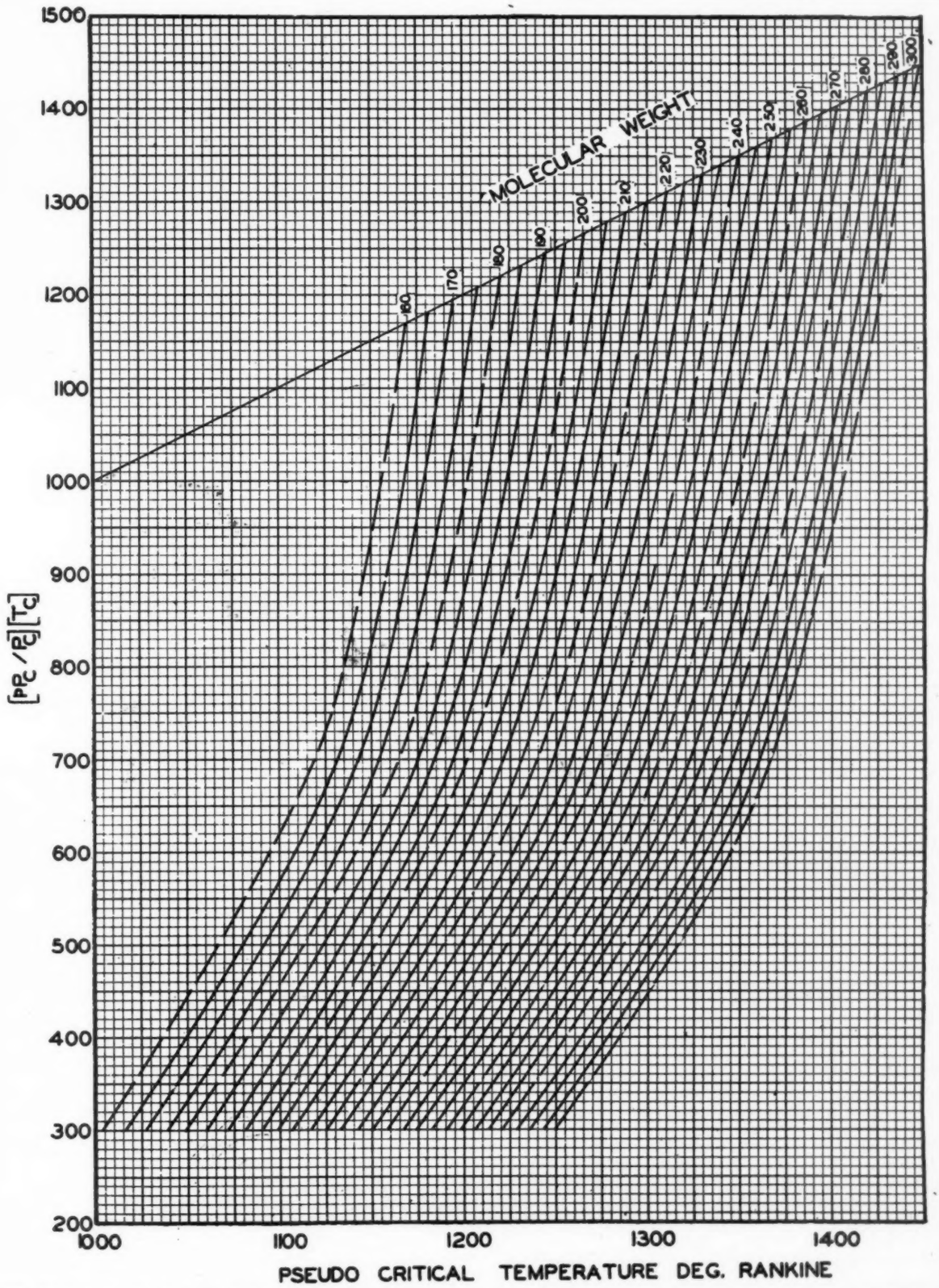
ARMY (E) NAVY — GREEN INSIGNIFIES SAFETY

HAZARD LAY·SET *Preformed* ROTARY LINES

THE CRITICAL PRESSURE OF A HYDROCARBON MIXTURE



NOTE: This table, the critical pressure of a hydrocarbon mixture computed from the pseudo critical temperature and the molecular weight gives the value for the ratio, $\frac{\text{true critical temperature} \times \text{pseudo critical pressure}}{\text{true critical pressure}}$. As the true critical temperature and pseudo critical pressure have been determined, this gives a value for the true critical pressure.

Chart by George Granger Brown, University of Michigan

Official Photos from International, Pathe, Acme

DO you want to see oil that is worth many times its weight in gold — oil on which the lives of men, and the fate of whole continents, may depend? Look at these photographs from the South Pacific.

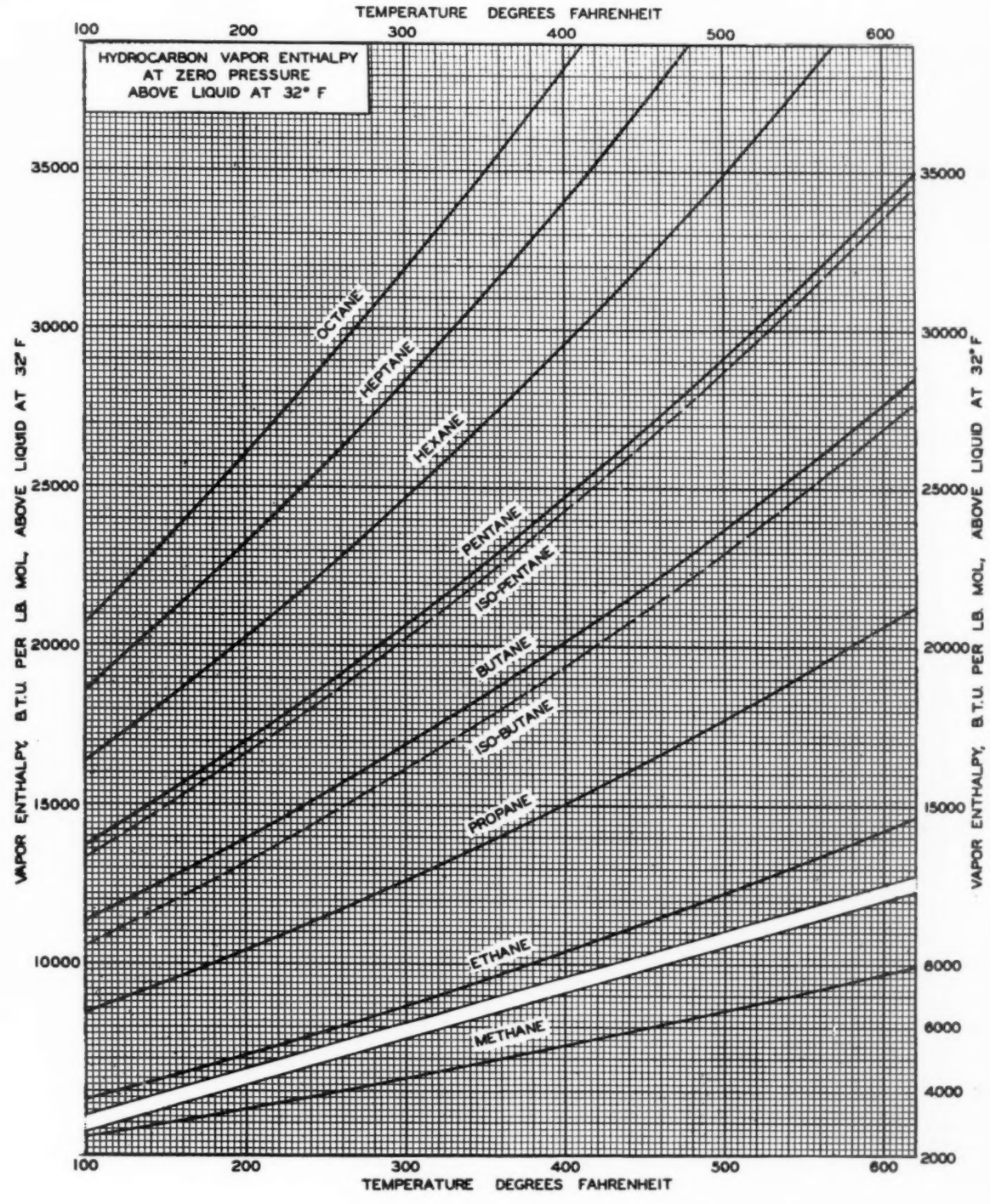
Do you want to see how this precious fuel — this "liquid ammunition" — is *protected?* Look at the drums. They are *hermetically sealed* with Tri-Sure Closures — sealed so tightly that *they can be rolled through the surf and exposed to torrential tropical storms* WITHOUT SEEPAGE.

"*Hermetically sealed*" — those two words will tell you why, all over the world, men who handle drums say, "*If it's in a Tri-Sure-equipped drum it's safe.*" And those two words — "hermetically sealed" — will tell you why Tri-Sure Closures will give *your product* the protection it should be getting from every hazard.

Tri-Sure
Reg. U. S. Pat. Off.
CLOSURES

AMERICAN FLANGE & MANUFACTURING CO. INC., 30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.
TRI-SURE PRODUCTS LIMITED, ST. CATHARINES, ONTARIO, CANADA

ENTHALPY OF HYDROCARBON VAPORS



NOTE: This chart replaces sheet 2 p 237.300.1 published in February, 1944.

—Chart by George Granger Brown, University of Michigan.

DON'T WASTE HEAT

SAVE IT with MAXIM HEAT RECOVERY SILENCERS

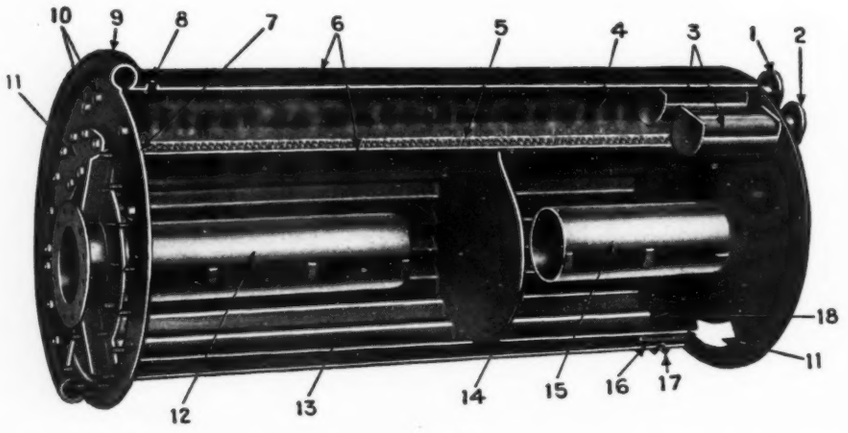
Maxim Heat Recovery Silencers convert waste exhaust heat into steam or hot water for industrial processing operations or for heating.

These Heat Recovery Silencers provide effective silencing of exhaust noise and are available with or without the spark arrestor feature.

A highly efficient heat transfer is achieved through high mass gas velocities and the use of extended heating surfaces. Because of this type of construction (no tubes) it is possible to run dry without damage to the unit. Automatic control of water level through steam pressure regulated valves controls steaming rate, and because the unit can be run with or without water, complete automatic control of output is possible.

Maxim engineers will be glad to work with you to determine the most efficient set-up for your particular case. Maxim Bulletins WH-100, WH-102 and WH-103, describing these Heat Recovery Silencers, will be sent to you on request.

For silencing, without the heat recovery feature, investigate the broad range of usefulness covered by Maxim Silencers . . . for internal combustion engine exhaust or intake, steam engine exhaust, air compressor intake, vacuum pump discharge, blower intake and discharge, high velocity steam, air or gas discharge. Engine exhaust silencers available with or without spark arrestor. Bulletins on request.



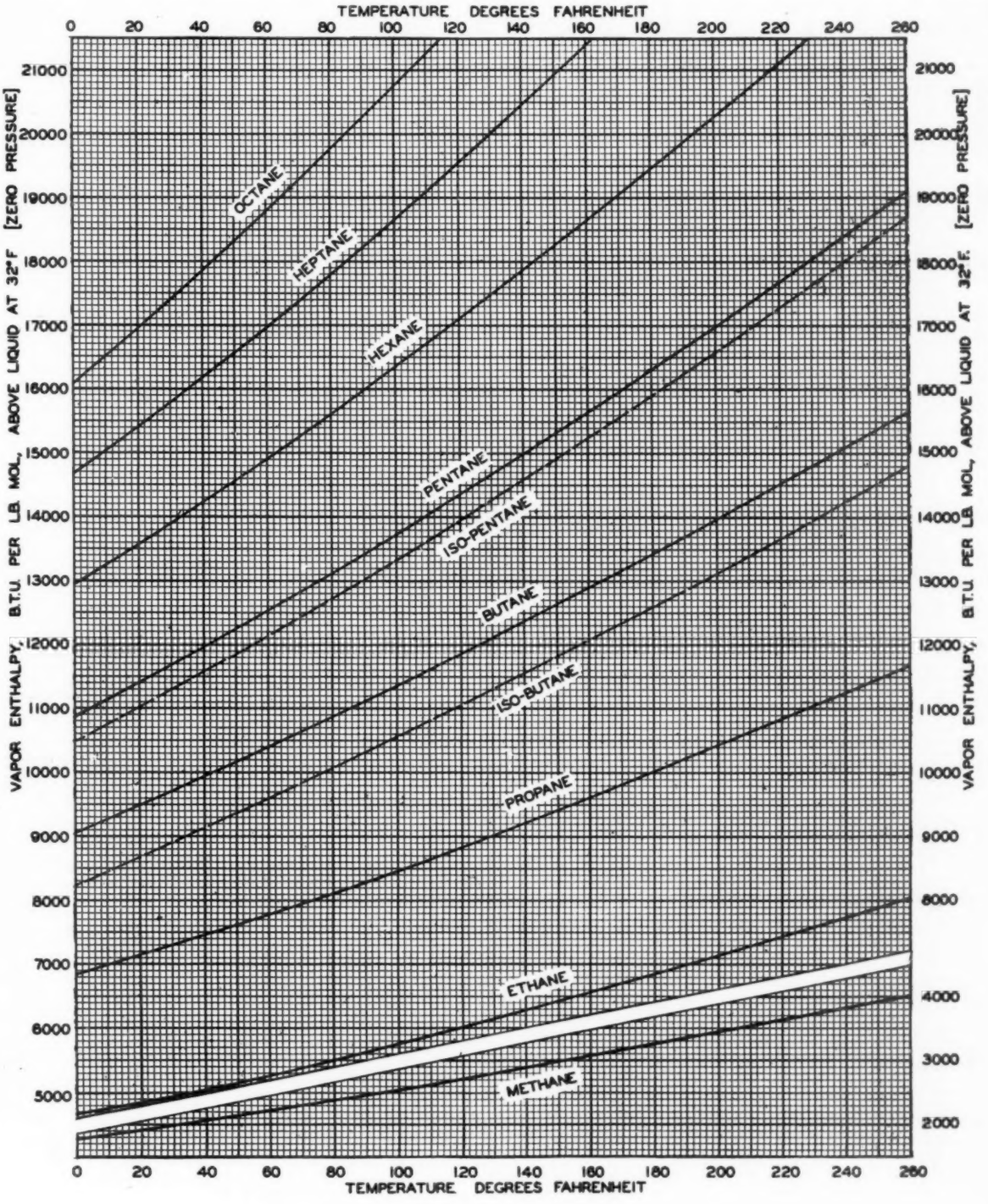
1—Steam Outlet
2—Safety Valve Connection
3—Dry Pipes
4—Steam Space
5—Water Line
6—Shells—Cylindrical to withstand steam pressure and pulsating gas flow
7—Inlet Head
8—Pressure Gauge Connection
9—Expansion Joint—permits dry operation
10—Water Gauge Connections
11—Cleanouts—provide easy access for cleaning heating surface
12—Inlet Bleeder Tube
13—Extended Heating Surface—forming conduits for leading exhaust gases from one attenuating chamber to the other
14—Insulated Intermediate Head
15—Outlet Bleeder Tube
16—Feed Water Deflector Plate
17—Feed Water Connection
18—Exhaust Gas Outlet from side conduits formed by extended heating surfaces

THE MAXIM SILENCER CO.
90 Homestead Ave., Hartford, Conn.

ARMY E NAVY

MAXIM

ENTHALPY OF HYDROCARBON VAPORS



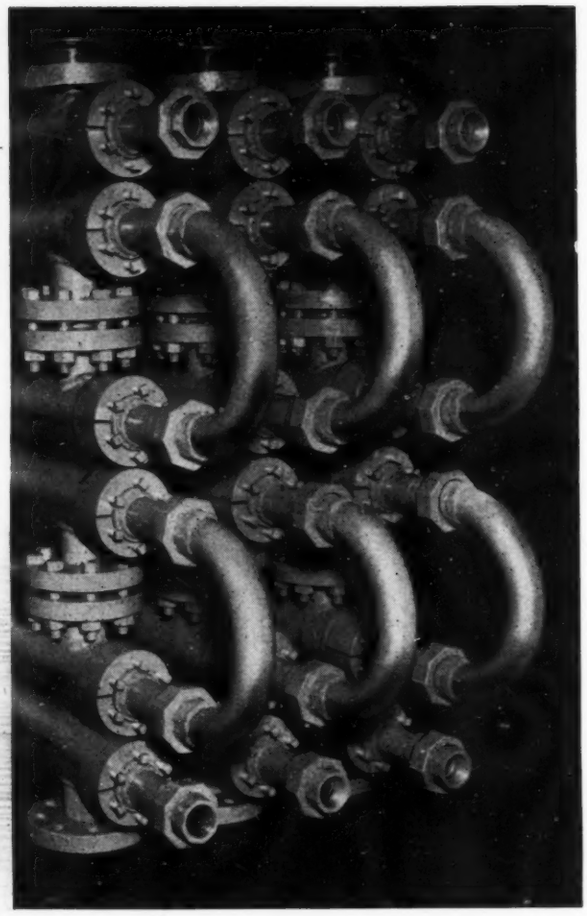
NOTE: This chart replaces sheet 2 p 237.300.1 published in February, 1944.

—Chart by George Granger Brown, University of Michigan.

Another Advantage of

BROWN FINTUBE

Sectional Heat Exchangers

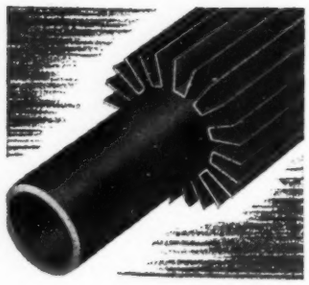


This

Easy to See... Easy to Assemble Gasketed Seal

★ Employing our newly designed "Positioning Fittings"—one part welded to the shell, and one part welded to the Fintube—sealed with a gasket, solid ring, and split collars provided with cap screws (see view above) this new front seal on Brown Fintube Sectional Heat Exchangers has won enthusiastic acclaim from operating and maintenance men.

This new seal is easily assembled and disassembled with only a small movement of the cap screws—and using a standard wrench—thus permitting the exchanger sections to be mounted side by side—saving space. It avoids lapped, gland, or ground joints—and since all parts are easily accessible for cleaning, the seal assures positive, tight closure—time after time—free from dirt—and without any outboard stress, or any torsional twisting of either the shell or fintube. The seal employs either composition or metallic gaskets—and holds exceedingly high pressures without "bleeding". . . But send for a copy of our Bulletin No. 432. It gives full details including dimensions of standard units and other data of much interest to engineers and operating men.



Brown Integrally-Bonded Fintubes are used in all Brown Fintube Heat Exchangers,—are available in Exchangers made by most other manufacturers,—and are ideally suited for many other heating and cooling services. Furnished in plain, "longitudinal," or "cut and twisted" types,—wide range of sizes in low carbon or special steels. Design assistance furnished gladly.

THE BROWN FINTUBE CO.

125 FILBERT STREET • ELYRIA, OHIO

MANUFACTURERS OF INTEGRALLY BONDED FINTUBES AND FINTUBE HEAT EXCHANGERS

PHYSICAL CONSTANTS OF HYDROCARBONS

Hydrocarbon	Specific gravity 20/4 °C.	M. P. °C.	B. P. °C.	Index of refraction n_D^{20}	Viscosity Abs. Poises	Spec. heat	Heat of vaporization Cal/G.	Heat of combustion K-Cal/mol.	Aniline point °C.	Coeff. of expansion °C.	Critical constants P Atm.	Critical constants T °C.	Critical constants D	Vapor pressure °C. mm.	Octane number Actual	Octane number Blending	Surface tension Flash °C.
$C_{10}H_{22}$ (contd.) 2, 3, 3-Trimethylheptane	0.7405*		157.6*	1.4170*				1615.1	74.0						70.0m		
2, 3, 3-Trimethylheptane	0.7488		160–160.1	1.4202				1615.1									
2, 2, 6-Trimethylheptane	0.7238	-105.0	148.93	1.40777				1615.1	81.0						78.7m	69.0m	
2, 4, 6-Trimethylheptane	0.7223		147.6	1.4071				1615.1	82.0						93.0m		21.18
3, 3, 5-Trimethylheptane	0.7384*		153.3*	1.4161*				1615.1	70.0						104.0m		
3-Methyl-3-Ethylheptane	0.7460		156.3	1.4179				1615.1	73.0						70.0m		
4-Propylheptane	0.7364		161.8	1.4150				1615.1	76.0						40.0m		
2, 2, 3, 3,-Tetramethylhexane	0.7601*		159.0*	1.4264*											97.0m		
2, 2, 3, 4-Tetramethylhexane	0.7511^{25}		156.6	1.4202^{25}				1615.1	70.0						102.0m		
2, 2, 5, 5-Tetramethylhexane	0.718		135.0	1.4057				1615.1	83.0						122.0m		
3, 3, 4. 4-Tetramethylhexane	0.7750*		165.5*	1.4340*				1615.1	64.0						123.0m	124r	
3, 3-Diethylhexane	0.7613*		169.6*	1.4258*				1615.1	69.0						65.0m		
3, 4-Diethylhexane	0.7514		160.7	1.4200				1615.1	73.0						62.0r	55r	

*Estimated.

See table P 771.001. B for footnotes.

Table from "Physical Constants of the Principal Hydrocarbons," 4th edition, by courtesy of copyright owner, The Texas Company.

The Truck that Barges In from the Sea

NAZI EYES POPPED in awed surprise when they first spotted our Army "ducks"... during the early Sicily and Salerno landings.

What kind of landing "boats" were these... that kept right on coming... that seemed to develop "land legs" as they hit the beach and climbed it and kept running at high speed along the roads?

Today, flocks of these "ducks" accompany our invasion forces everywhere... to deliver the tons of food, water, and gasoline needed during each landing.

Twenty-one HyattRollerBearings carry the load for each of these double-duty trucks... that "barge" in from the sea.

It takes a bearing like Hyatt to withstand such punishment... *the terrific impacts of landing and climbing, the churning of the wheels in sand and water.* Only a bearing which has precision, capacity, and toughness can handle these load extremes.

Everywhere in vital war equipment, heavily loaded shafts, gears and wheels do their jobs supremely well when they turn on Hyatt Roller Bearings.

Smooth rolling Hyatts, manufactured with microscopic accuracy, bring easily sustained operation and dependability *not only to fighting equipment,* but also to the machines which help build it.

That's Hyatt's assignment in war and peace... to serve and save... to carry on through long hours and adverse weather conditions, extreme speeds and shock loads... to prolong machine life... to *keep equipment going!*

Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.

HYATT BEARINGS

DIVISION OF

GENERAL MOTORS

Storage tank, 13,500-bbl. capacity. Such tanks, as well as those of 50,000-bbl. capacity, are lined to protect fuels from contamination and facilities from corrosion

PETROLEUM ENGINEER Exclusive Feature

by

C. G. Munger

Amercoat Division,
American Pipe and Construction Company

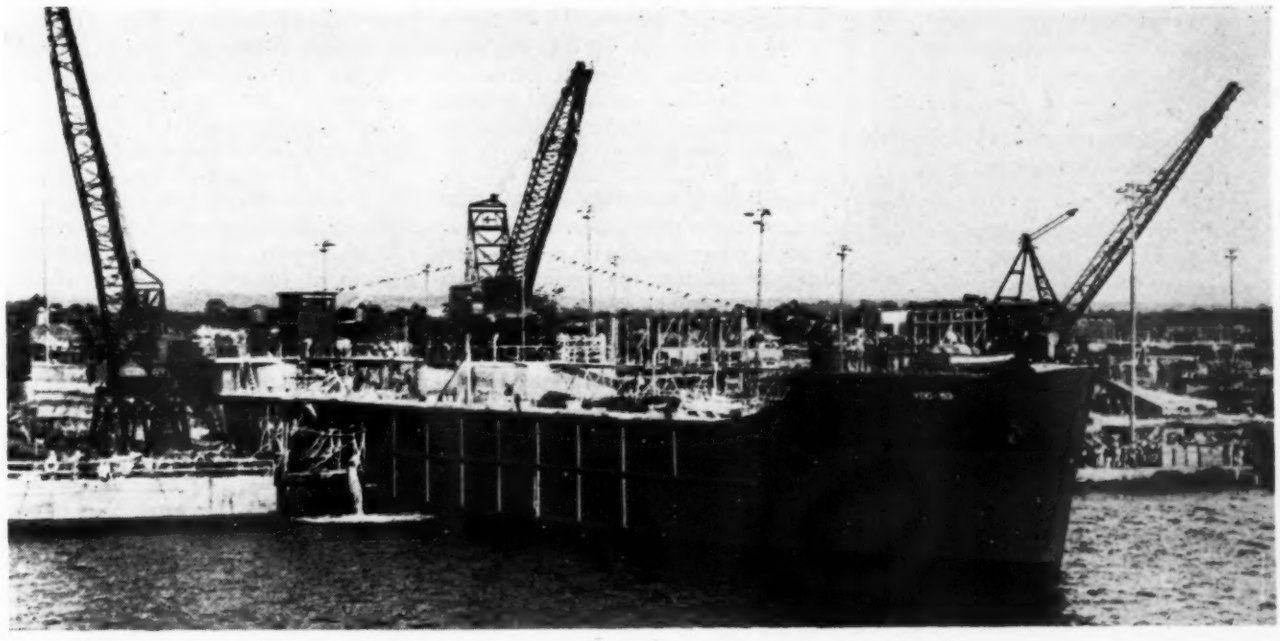
Concrete Tanks For Storage Of Petroleum Products

☆ **Interior is lined to prevent seepage and contact of gasoline with concrete**

TYPICAL examples of the wartime search for new materials and new uses of old materials are the development of plastics to replace various metals; plywood for airplane and glider construction, and the extensive use of concrete as a substitute for steel in storage tanks.

Recent development and use of the prestressed reinforced concrete design for cylindrical tanks by the United States Navy Department have greatly increased the effectiveness of concrete tanks for many purposes. Such tanks require less steel than is necessary in conventional concrete tanks and are practically free from cracking, as the steel reinforcing is under tension and

Exterior surfaces of this concrete ship were coated to prevent corrosion. Interior cargo holds also were coated



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Every oil man should carry a Lufkin "Mezurall" Tape-Rule. It easily slips into your vest pocket—weighs but 3 ounces. The ½ inch wide blade, stiffened by concave forming, can be projected unsupported yet will flex to measure curves or odd shapes. With a "Mezurall" you can take exact inside or outside measurements. End hook permits you to take out-of-reach measurements.

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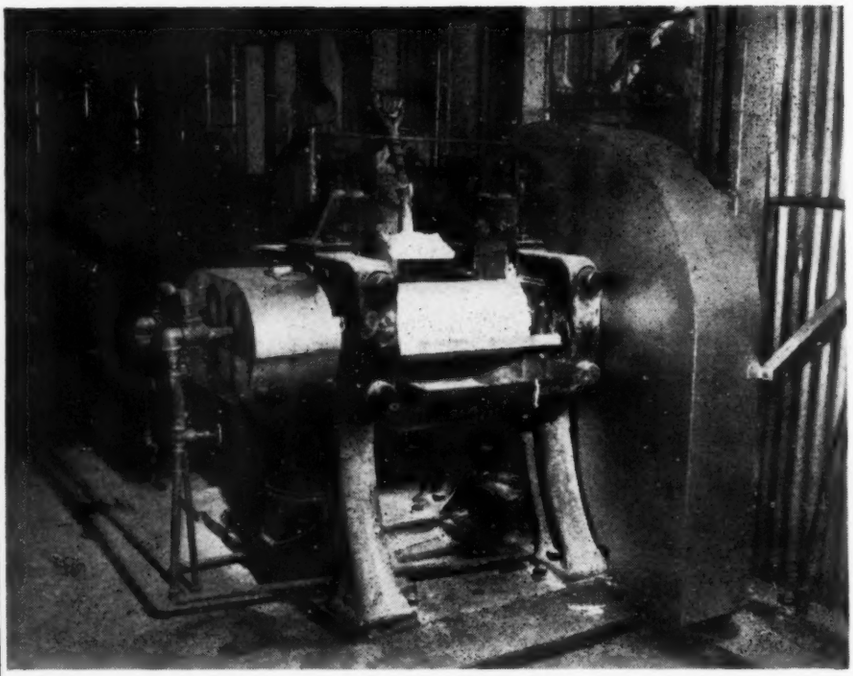

Differential 2-roll mill unit used to obtain uniform pigment dispersion

the concrete under compression. In design, the steel is applied in bands similar to those on a wooden stave tank; the tighter the bands are drawn, up to a certain point, the tighter the tank and the less subject it is to cracking.

The greatest use for this type of tank has been in the storage of petroleum products, such as diesel oil, motor gasoline, and 100-octane aviation gasoline. As concrete reacts to many chemicals and is porous to highly penetrating fuels it was therefore necessary to coat the interior of these new design concrete tanks. The coating must prevent seepage and loss of fuel through the concrete and also, in the storage of aviation gasoline, prevent contact of the gasoline with the concrete itself, which is alkaline.

The coating must provide this two-way protection. It should restrict or prevent capillary action and prevent corrosion caused by chemical reaction. It should also prevent destructive action of certain gases and seepage by penetrating liquids other than water.

Coating for these concrete fuel tanks must be non-reactive with new concrete surfaces and must not contain oil that will saponify. It must provide an inert, impermeable surface coating completely insoluble in fuel oil, diesel oil, and aromatic aviation gasoline in order to prevent contact and chemical reaction between tank and contents, eliminating all possibility of tank corrosion and content contamination.

A new thermoplastic coating compound[1] that meets these strict requirements has been applied with enduring success to a large number of concrete diesel oil and aviation gasoline tanks, and also to the interior of concrete ships.

When applied cold with spray or brush to concrete, wood, or metal, it forms a tight, tough, smooth, impermeable coating that is tasteless, odorless, and chemically inert. It withstands considerable abrasion and yet is not brittle. Before the war, after three years' exposure to 100-octane aviation gasoline, it still maintained its high gloss, toughness, and excellent adhesion. There was no change in the aviation gasoline. At the start of the war, the coating compound was used with the newly-enriched aviation gasoline consisting of 100-octane aviation gasoline, toluol, xylol, and benzol.

Results since then show that this highly aromatic fuel acts only as a plasticizer for Amercoat, making the coating even more flexible without reducing its other properties. Extraction tests of the stored gasoline gave excellent results. Besides being extremely resistant to petroleum hydrocarbons, these coating compounds have high chemical resistance to acids, alkalies, and salts. They are entirely insoluble to all aliphatic and poly alcohols. The coating is dielectric, resisting electrolysis. It has an extremely low water absorption and because it contains no paint oils, will not oxidize, hydrolize, or saponify. It is easy to apply and easy to repair.

Successfully used as a coating for concrete storage tanks for diesel oil and aviation gasoline, the compound is also widely used throughout industry, notably the food, chemical, and transportation industries. ——— ☆ ☆ ☆

[1]Amercoat, manufactured by the American Pipe and Construction Company, Los Angeles, is a compound of synthetic resins (vinyl) combined with solvents and non-toxic, non-reactive pigments.

NINE FOOT TWO . . . SEAMLESS . . . TRUE

Another example of Taylor Forge "know-how" that means extra value in WeldELLS

Turning out a 110" O.D. SEAMLESS Steel Flange to rigid specifications of accuracy isn't exactly the easiest job in the world. But tough jobs are not unusual here at Taylor Forge. In fact, this one is quite typical of the kind that is so often assigned to us by engineers who feel we are a little better at it than any other organization.

For a good many years these "unusual" things have been the usual at Taylor Forge . . . doing things with hot metal that nobody else does . . . knowing just how to control its flow and form under pressure and impact.

And in the final analysis there is no better example of this than your old friends WeldELLS and other Taylor Forge welding fittings themselves. For while WeldELLS represent our regular line of welding fittings, they reflect forging operations that are *far* beyond the usual!

Check down the list of WeldELL features and you will see how true this is. Only Taylor Forge knowledge and methods could give you a fitting with tangents and selective distribution of metal in an extremely accurate, seamless forging! Add to this the features of WeldELLS which cut welding time and costs, and you have the fittings that . . . *"have everything"!*

No other welding fittings combine these features:

- **Seamless** — greater strength and uniformity.
- **Tangents**—keep weld away from zone of highest stress—simplify lining up.
- **Precision quarter-marked ends** —simplify layout and help insure accuracy.
- **Selective reinforcement** — provides uniform strength.
- **Permanent and complete identification marking**—saves time and eliminates errors in shop and field.
- **Wall thickness never less than specification minimum**—assures full strength and long life.
- **Machine tool beveled ends**—provides best welding surface and accurate bevel and land.
- **The most complete line of Welding Fittings and Forged Steel Flanges in the World** — insures complete service and undivided responsibility.

WeldELLS *have everything*

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N.G.A.A. Program

The tentative program of the Natural Gasoline Association of America meeting, to be held at the Baker Hotel, Dallas, Texas, April 12, 13, and 14, has been released as follows:

APRIL 12, 2:00 P.M.

"Time," by N. G. A. A. President James W. Vaiden, vice president, Skelly Oil Company.

"Why and Where to Build a Natural Gasoline Plant," by Frank Matheny, superintendent, Natural Gas and Gasoline Department, Phillips Petroleum Company.

"Infra Red Spectrograph Analysis of Natural Gas Hydrocarbons," by H. Cary, National Technical Laboratories.

"Centrifugal Compressors and Their Application in Natural Gas and Natural Gasoline Operations," by E. O. Bennett, engineering consultant.

Technical Committee Report, by M. R. Church, Shell Oil Company, Inc., Houston, covering work by that group on fractional analysis, hydrocarbon constants, L.P.G. sulphur determination.

APRIL 13, 10:00 A.M.

"The Future of Liquefied Petroleum Gases." This paper is to be a symposium of opinion on the supply of these products in: (1) rest of the war period; (2) immediate postwar period, and (3) three to four years of peace time developments.

Address, James E. Pew, director, Natural Gas and Natural Gasoline Division, PAW.

"Catalytic Cracking, Asset or Menace to Natural Gasoline Operations," by D. P. Barnard, associate director of research, Standard Oil Company of Ind.

Presentation of the Hanlon Award.

2:00 P.M.—*High pressure gas session*

"Unitization of Condensate Pools," by Roy L. Benoit, Ohio Oil Company.

"Operating Economies of Unitization," by Jack Flaitz, Distillate Production Corporation.

"Condensate Gas Sampling," by Dr. G. G. Brown and Dr. D. L. Katz, University of Michigan.

Discussion by Kenneth Eilerts, senior chemist, U. S. Bureau of Mines.

APRIL 14—*"Information Please" session*

9:30 A.M. and 2:00 P.M.

The purpose of this session is to provide a forum where executives and technical men of the natural gasoline and condensate industries can question the leading authorities on processing, production, and operating trends.

The interlocutor will be D. E. Buchanan, who will be assisted by H. W. Harts, Warren Petroleum Corporation, chairman; R. G. Atkinson, Shamrock Oil and Gas Corporation; I. Earl Nutter, Hagy, Harrington and Marsh, and W. W. McNeal, Jr., J. S. Abercrombie Company.

Invited to participate as members of the panel are the following:

Representating process companies: Gustav Egloff, Universal Oil Products Company, Chicago; John Ford, M. W. Kellogg Company, New York, and A. J. L. Hutchinson, The Fluor Corporation, Los Angeles.

Representing design and construction companies: M. F. Kotzebue, Gasoline Plant Construction Company, Houston; P. M. Raigorodsky, Petroleum Engineering, Inc., Tulsa, and Henry Wade, Stearns-Roger Manufacturing Company, Denver.

Representing the Petroleum Administrator for War: James E. Pew, director of Natural Gas and Natural Gasoline Division.

Representing the refining industry: D. P. Barnard, Standard Oil Company.

Engineering consultants: Dr. G. G. Brown, University of Michigan, Ann Arbor, Michigan, and Dr. E. O. Bennett, Houston.

Representing production and research: R. C. Alden, Phillips Petroleum Company, Bartlesville, Oklahoma; Stuart Buckley, Humble Oil and Refining Company, Houston, and P. S. Magruder, General Petroleum Corporation, Los Angeles.

***To all* NATURAL GASOLINE MEN**

Greetings

from the

NATURAL GASOLINE SUPPLY MEN'S ASSOCIATION

we are looking forward to seeing you at the

Twenty-Third Annual Convention of the

NATURAL GASOLINE ASSOCIATION OF AMERICA

April 12-14, Baker Hotel, Dallas, Texas

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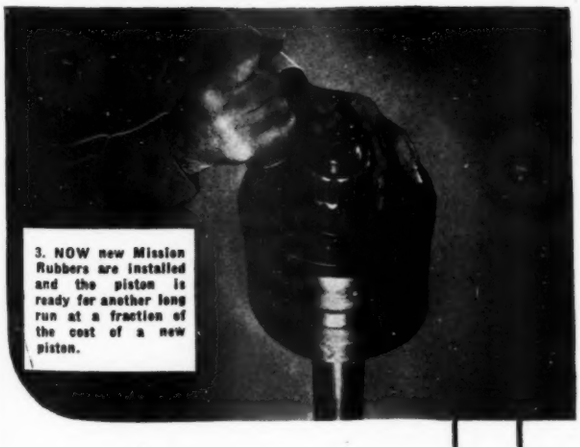
MISSION PISTONS

Save important war materials . . . and save you money

1. When rubbers are worn, you don't have to throw away the entire piston. Simply remove the old rubbers and save the body.

2. It's not even necessary to remove the piston body from the rod. You save on shut-down time when rubbers are changed.



3. NOW new Mission Rubbers are installed and the piston is ready for another long run at a fraction of the cost of a new piston.

1. SAVES VITAL WAR RUBBER

Advanced design and extremely tough rubber compound give Mission Piston Rubbers extra long life.

2. SAVES VITAL WAR METAL

because of the Mission principle of "Change the rubbers and save the piston."

After a long uninterrupted run you renew the piston by simply installing new rubbers at the rig, without removing the piston from the rod. You save the cost of the piston body which is about half the cost of the entire piston. You salvage the worn rubbers for the war effort.

GUARANTEED { to be the most economical piston on the market to operate. }

CHANGE THE RUBBERS AND SAVE THE PISTON

MISSION MANUFACTURING CO.

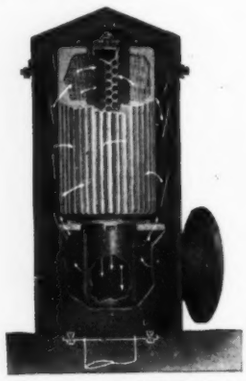
HUMBLE ROAD, HOUSTON, TEXAS

EXPORT OFFICE: 30 ROCKEFELLER PLAZA, NEW YORK

MACHINERY and EQUIPMENT

Intake Filter

PARTICULARLY in the case of intakes for air compressors, authorities recommend placement of intake pipe openings outdoors where air is



Staynew Model IDR Intake Filter sectional view

cooler. Frequently, high level placement is also recommended to avoid concentrations of dust and dirt more likely to be present nearer the ground.

Very often, placing the air intake opening inside presents an air filter service problem, as servicing is frequently neglected when personnel must work in cold, snow, or rain, particularly if trips to slippery, wind-swept roofs are required.

To solve this problem, Dollinger Corporation (formerly Staynew Filter Corporation), has recently developed a new intake filter for compressors and internal-combustion engines. This new filter may be installed and subsequently serviced at ground level—right in the engine room itself, if preferred—while the air intake opening may be located elsewhere at the most suitable point.

The new filter provides all the advantages of the well-known Staynew and Protectomotor dry type intake filters, including the exclusive radial fin construction, it is stated. Combination silencer-and-filter models are available.

Servicing is extremely simple, as the actual filter insert can be lifted out through a removable panel, and either cleaned by brushing, by compressed air, or by washing.

Arc Welder

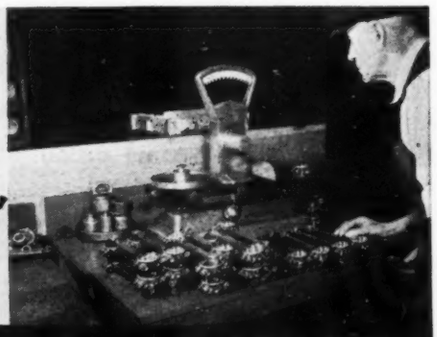
A NEW "shield-arc" engine-driven welder rated at 200 amp., of light weight, rugged construction with powerful enclosed, rubber mounted engine of 29 hp., is announced by The Lincoln Electric Company, Cleveland, Ohio.

This new unit, supplied complete with base and canopy (see accompanying photograph) has a current range of 40 to 250 amp. Dual control of welding current is accomplished by adjusting series fields and generator speed.

For metallic arc welding, with bare or coated electrodes, the new model also supplies uniform welding current for carbon arc welding.

The generator control or "job selector" assures accuracy of open circuit

BALANCED RODS... another "PLUS FEATURE" built into all



WISCONSIN Air-Cooled ENGINES

Every connecting rod, in every Wisconsin Air-Cooled Engine, is precision-balanced to eliminate all weight variations in excess of ¼-ounce per rod.

This is admittedly cutting it pretty fine for a rough-and-ready heavy-duty engine . . . but not *too fine* for these fine engines. Smooth operation, reduction of vibration to a negligible minimum, prevention of excessive wear . . . these are factors that can be controlled only by the most meticulous care and attention to such small details as this in building an engine.

The *value* of this attention comes into play when a Wisconsin Air-Cooled Engine powers your equipment.

Most H.P. per pound

WISCONSIN MOTOR Corporation

MILWAUKEE 14, WISCONSIN, U. S. A.

World's Largest Builders of Heavy-Duty Air-Cooled Engines

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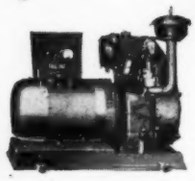

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STERLING MACHINERY CORPORATION

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voltage and permits precise control of engine speed of from 1500 to 1150 r.p.m. for welding. In addition, this control may be used manually to reduce the engine speed to as low as 750 r.p.m. whenever it is necessary to stop

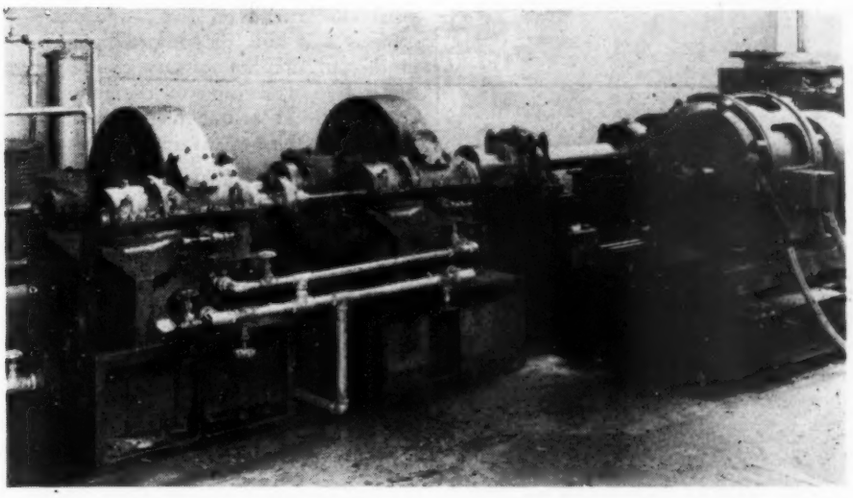
welding at intervals of a few minutes. This feature not only permits adjustment of engine speed to fit the individual job, but also affords improved welding and keeps down fuel consumption and engine wear.

With this new unit an engine speed of from 1150 to 1400 r.p.m. is used for the majority of welding applications. Being considerably lower than that of conventional engine-driven welders it assures long life of the equipment.

The generator can produce its rated current of 200 amp. when the job selector is set so that the machine operates at speeds as low as 1200 r.p.m.

Weight of the unit as illustrated is approximately 1130 lb. Overall length is 65¼ in.; width, 24 in., and height, 41½ in. Bulletin 312-C, describing the welding unit, is available on request.

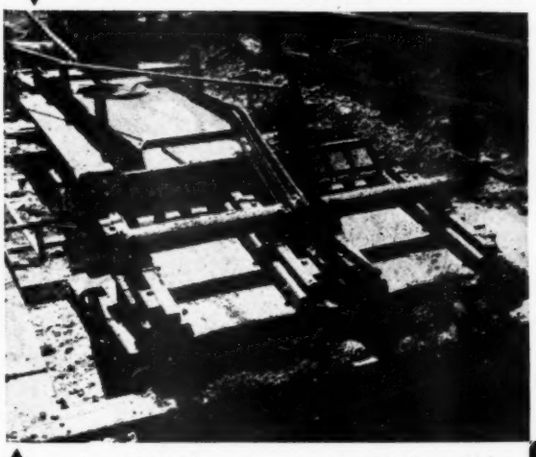
On the Test Block



THE accompanying photograph illustrates turbo-electric herringbone gear generators manufactured by Lufkin Foundry and Machine Company, Lufkin, Texas, for navy ships. The finest precision work is required on these turbo-electric generators, the pinion traveling at 10,000 r.p.m.

Lufkin was able to convert quickly its facilities from peacetime to war production of turbo-electric generators, ship propulsion gears (1000 hp.) and General Sherman tank gears. The company is fast turning back to civilian production of oil field pumping units as plant equipment is released.

LINK-BELT KEEPS THIS ROTARY MUD *in Top Condition*



● Link-Belt is keeping this drilling job safer by keeping the rotary drilling mud properly reconditioned . . . continuously removing damaging abrasive materials from circulation. Link-Belt first developed mud screens for the oil industry and is still first in developing modern improvements.

9270

Two Link-Belt mud screens mounted on skid as one unit (having but one mud-collecting tank and inlet chute) operate independently, although driven from single power source, a 5 H.P. steam turbine (or 2 H.P. electric motor). Send for Folder 1872-A.

LINK-BELT COMPANY

Philadelphia 40, Houston 2, Dallas 1, Los Angeles 33, New York 7, Toronto 8. Sold by most supply houses

LINK-BELT MUD SCREEN

THE VIBRATING SCREEN THAT HAS EVERYTHING

Free Examination

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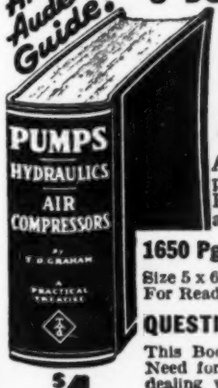

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P E N

STOODY SELF-HARDENING MAKES THE DIFFERENCE!

ABOVE are two reclaimed rollers taken from the same tractor. The upper roller was rebuilt to size with high carbon electrodes alone, but the lower roller carried a protective layer of Stoody Self-Hardening over the high carbon build-up*.

Abrasive conditions encountered in tractor operation were so severe the top roller was worn out in three months' time. The Stoody Self-Hardening, however, kept the lower roller in operation for another three-months period, a life increase of 100%!

Cost of the Stoody Self-Hardening deposit can be ignored, considering benefits obtained and the time saved in eliminating an extra overhaul.

Hard-facing can be applied either of two ways: (1) A bead run around the outer edge and space between the bead and collar filled in with horizontal welds or (2) A bead around the outer edge to bring the roller back to diameter, and intervening area between outer edge and collar filled with a continuous spiral of hard metal. Either method is equally successful but the latter has the advantage of more easily maintaining roller concentricity.

Have you received your copy of Stoody Specification Sheets? They illustrate and describe dozens of equipment-saving applications thru the use of hard-facing—sent free on request.

*The preliminary high carbon build-up can be eliminated if Stoody Self-Hardening is applied before excessive wear has occurred on the roller.

STOODY COMPANY
1142 W. SLAUSON, WHITTIER, CALIF.

STOODY HARD-FACING ALLOYS
Stop wear... Eliminate Repair

Pulsameter

THE Pulsameter is an instrument for measuring the differential pulsation amplitude across an orifice meter. Where orifice meters are situated near compressor stations, pulsations are usually present. The magnitude of these pulsations depends on local conditions—number and kind of compressors, piping layout, etc. Special tests conducted under the supervision of the joint A. G.A.-A.S.M.E. orifice meter committee have established maximum limits of differential pulsation amplitude (as measured by the Pulsameter) versus meter differential under which accurate measurements may be obtained.

When in use the Pulsameter is connected to the orifice meter piping and by means of a tension spring adjustment and an indicating light the reading is obtained. From this maximum differential pulsation amplitude and the recorded differential reading on the orifice meter it can be determined whether accurate measurement may be obtained under the pulsation condition existing in the orifice meter installation.

This apparatus is being manufactured by The Refinery Supply Company, Tulsa, Oklahoma.

General Purpose Stock

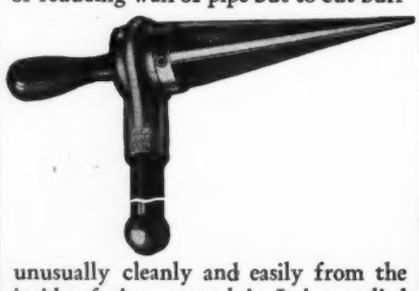
A GENERAL purpose stock for use in oil seals, gaskets, "O" rings, and other types of fuel seals and parts requiring resistance to heat and oil, has been developed by Los Angeles Standard Rubber, Inc.

The new buna N stock in addition to its high heat and oil resistant qualities, is flexible to minus 35° F.

The company, which recently moved into its new plant at 1500 East Gage Avenue, Los Angeles, manufactures all types of rubber products.

Pipe Reamer

A NEW pipe reamer of extra long taper design has been added to its line of pipe tools by The Ridge Tool Company of Elyria, Ohio. As a result of the long taper, this Ridgid reamer is said not only to avoid flaring, splitting, or reducing wall of pipe but to cut burr



unusually cleanly and easily from the inside of pipe or conduit. It is supplied with ratchet handle, or can be used with the ratchet handle of Ridgid No. OOR ratchet threader.

WEIGHT INDICATOR POINTS

It's no accident that the Martin-Decker Unitized Mud Pump Gauge is the world's finest, most sensitive and rugged instrument for measuring slush pump pressure. The oil industry's leading weight recording measurement and control concern devoted years of development work to combining a special indicating gauge, a patented diaphragm unit, and a built-in pulsation damper in one unitized instrument requiring no tubing or fittings for connection. And best of all, it can be moved from location to location on a moment's notice.

★

MARTIN-DECKER CORP.
LONG BEACH, CALIFORNIA
A. F. McQUISTON, BAKERSFIELD, CALIFORNIA
REED ROLLER BIT CO., HOUSTON, TEXAS

New Houston Plant

Wailes Dove-Hermiston Corporation, Westfield, New Jersey, is constructing a new plant at Houston, Texas, to supply the needs for bitumastic pipe coating in the southwest, which will complete a cross country chain of manufacturing facilities: Westfield, New Jersey; East St. Louis, Illinois; Houston, Texas.

The new plant is at 7002 Clinton Drive. A siding of the Houston Belt Terminal Railway serves the property. Freight shipments to all parts of the southwest can be made quickly. Ample facilities will be available for loading trucks.

The plant is of fireproof construction and contains modern up-to-date manufacturing equipment and a control laboratory.

The first shipments of bitumastic priming solution and bitumastic XXH enamel will be made for the protection of the Tennessee Gas and Transmission Company pipe line now under construction. This is a pipe line from Corpus Christi, Texas, to Kenova, West Virginia.

C. E. Burt with Grant Tool

The merger of the Sorensen-Burt Manufacturing Company, a co-partnership consisting of A. W. Sorensen and C. E. Burt, with the Grant Oil Tool Company, returns C. E. Burt to the oil industry with which he was associated for 23 years, having been with General Petroleum Corporation, and for 20 years with Baker Oil Tools, Inc., as vice president and manager of engineering and production.

Burt's duties with the Grant Oil Tool Company are as vice president and assistant general manager.

Alton Hall Appointed

Alton Parker Hall has been appointed assistant general manager of sales of American Chain and Cable Company, Inc. He assumed his duties March 1, with headquarters at 230 Park Avenue, New York.

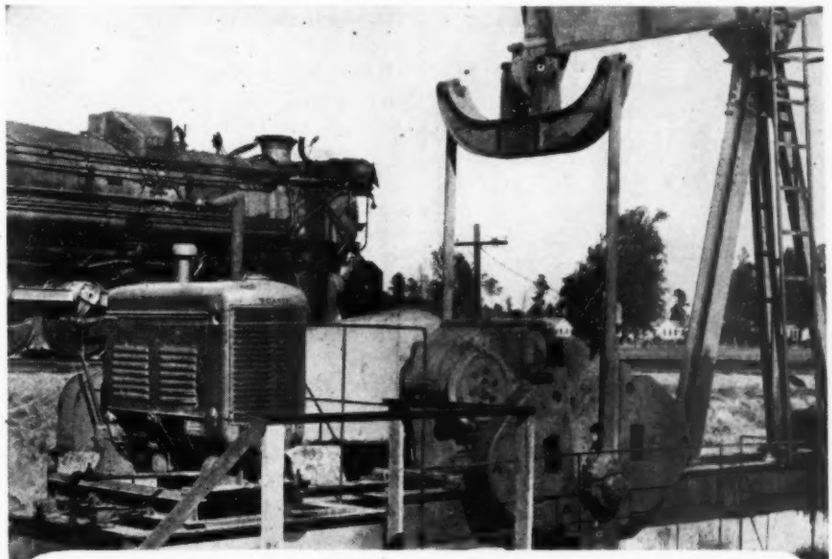
Hall has been with Bethlehem Steel Company since 1922, having served in the operating department and in the sales department since 1925. He has been assistant manager of sales of the New York office since March 1, 1938.

Awarded "E" Star

The Army-Navy "E" Star award, a renewal of the "E" award given previously, was presented informally at the Coffeyville, Kansas, plant of The Parkersburg Rig and Reel Company recently. At the request of the Navy Department, no ceremony was held.

A total of 132 new employees, who were not with the company when the "E" award was given, were presented "E" pins by Lt. A. R. Gruss, resident inspector of naval material, and R. J. Hansen, superintendent of the Coffeyville plant.

Lt. Gruss, in speaking of the award, stated "The Navy 'E' stands for outstanding performance of the men in the fleet. Without the outstanding materials supplied by you men and women of The Parkersburg Rig and Reel Company, units of the fleet could not earn the Navy 'E' so to commend you, you are awarded this highest of industrial honors."



PACKS MORE PUMPING HOURS

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WHATEVER you mean by Endurance . . . hours without shutdown, months without minor maintenance, or years before major overhaul . . . you can look for a lot of it in Case Oilfield Engines. Their record reveals many non-stop runs of months and sometimes years.

Such endurance comes not only from abundance of strong points, but more especially from absence of weak points. It comes not only from a habit of building engines a bit better than need be, but from a hundred years' experience in building machines sturdy and simple. It comes, too, from the fact that Case Oilfield Engines take so little routine attendance that there is less likelihood of slighting it.

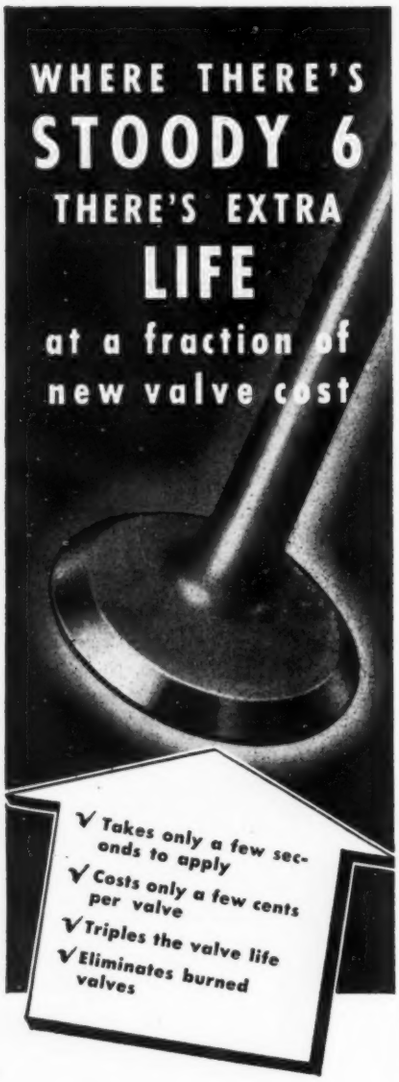
If you have Case Engines now, make sure they get the little care they call for regularly, so that you will get all those extra pumping hours. If you need more pumping power, ask your Case distributor about the possibility of supplying you. J. I. Case Co., Racine, Wis.

DISTRIBUTORS

Southwest Equipment Co., Dallas and Kilgore, Texas
Leland Equipment Co., Tulsa, Oklahoma

CASE KEEP ON BUYING WAR BONDS

CASE OIL FIELD ENGINES
are now available for prompt delivery from Texas stocks.
SOUTHWEST EQUIPMENT CO.
DALLAS AND KILGORE, TEXAS



THIS folder outlines the simple procedure any garage or shop equipped with acetylene welding equipment can follow. Eliminate your worries about valve replacements and save money as well. Write for folder

"Weld New Life Onto Worn Valves With Stoody 6"—no obligation.

STOODY COMPANY
1142 SLAUSON AVE., WHITTIER, CALIF.

STOODY 6-THE METAL THAT ADDS EXTRA MILES TO EXHAUST VALVE LIFE!

Mid-Continent Personnel

Harry O. Powell has been named vice president of the Mid-Continent Supply Company, general offices, Mid-Continent Building, Fort Worth, Texas. Powell, widely known in the petroleum industry and a foremost authority on oil country tubular goods, has been manager of Mid-Continent's tubular sales and will continue to supervise this division of the company's expanding operations.

H. O. POWELL

Merrill F. Cribbs, well known in the petroleum suppliers industry and recognized as an expert on oil country machinery, is now associated with Mid-Continent as its chief engineer. Cribbs is at the company's general offices.

S. R. CLINKSCALES

M. F. CRIBBS

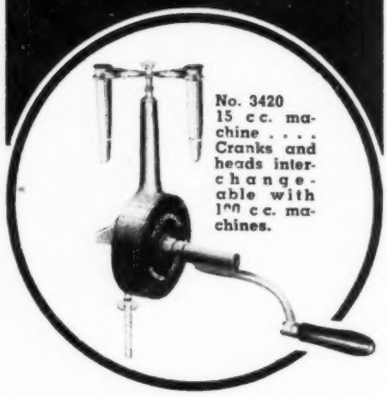
S. R. Clinkscales, prominent in oil well supply circles for many years, and during the last year in charge of material, District 2, Tulsa, Oklahoma, Petroleum Administration for War, is a new member of Mid-Continent's growing organization. Clinkscales will make his headquarters at the company's division offices, Philtower Building, Tulsa, as division tubular manager.

Joins Tube Turns

G. Bronson Philhower has recently been added to the staff of the New York office of Tube Turns, Incorporated, to represent the firm in metropolitan New York and New England.

WANTED—Construction superintendents and general foremen for general construction work. Must be familiar with all phases of construction in refineries and chemical plants. Should have some knowledge of operations. Give complete information, age, education, experience, ability, salary, availability, draft status. Replies confidential. Reply to Box 1, c/o The Petroleum Engineer, 700 Allen Building, Dallas, Texas.

For QUICK, ACCURATE TESTS
Use CURTIN CENTRIFUGES



Simple in design . . . Ruggedly built . . . Require no special care . . . Great Ratio and throw of crank produce required speed with no strain. Curtin Centrifuges meet all *A.S.T.M. Standard Method D-96-40* and *A.P.I. Code No. 25* requirements. Fully descriptive literature upon request.

W·H·CURTIN & CO. Inc
HOUSTON TEXAS

WANTED
MECHANICAL ENGINEER

Graduate mechanical engineer with 7-10 years oil refinery engineering experience wanted for development work. Permanent position offered by a long-established AAA-1 company, manufacturing fractionating and pressure vessels, heat exchangers, cast-steel flanged fittings and other equipment for the petroleum and process industries. Knowledge of cast-steel header boxes desirable. Successful applicant will report directly to plant manager. Location in southwestern city where ample housing facilities exist. If you feel qualified for this key position in an expanding organization, apply giving full information and enclosing small photograph. Replies will be held strictly confidential. Maximum salary—$5000 per year.

Box 14, c-o
PETROLEUM ENGINEER
701 Allen Building

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Over Boiler Scale and Corrosion Is Ever Yours . . . Use

SAND-BANUM!

A PEACEFUL Boiler Serves Better and Longer.

Write for FACTS Today.

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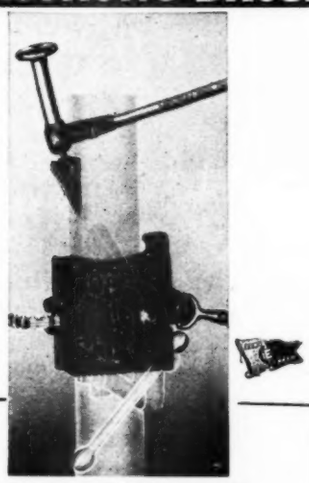
Look for the Arm-and-Hammer

ARMSTRONG BROS.



RATCHET PIPE REAMER and PIPE VISE SADDLE

Use an ARMSTRONG BROS. Ratchet Pipe Reamer to assure full capacity, trouble-free pipe work. Its spiral fluted reamer quickly eliminates all inside burrs for it is milled, ground and hardened. Its drop-forged reversible ratchet operates in the closest quarters—only a 12½-degree handle swing required. Will give lifetime service.

The ARMSTRONG BROS. Pipe Vise Saddle brings the vise to the point of work. Attaches instantly to any pillar or post and provides a secure base (and pipe or conduit bender) for either hinged, chain or open side pipe vises.

Write now for full description catalog C-639a

ARMSTRONG BROS. TOOL CO.
"The Tool Holder People"
333 N. FRANCISCO AVE. CHICAGO, U.S.A.
Eastern Warehouse & Sales, 199 Lafayette St., New York

Barrett Appointments

The Barrett Division of Allied Chemical and Dye Corporation announces the appointment of Charles T. Davis as protective coating representative in Texas,

T. F. KELLY

CHAS. T. DAVIS

Louisiana, Mississippi, Alabama, Arkansas, Florida, and New Mexico.

At the same time it was announced that T. F. Kelly takes over a new assignment, that of contacting all corrosion engineers from coast to coast in the development of cathodic protection, used with modern protective coating.

W. C. Norris Promotions

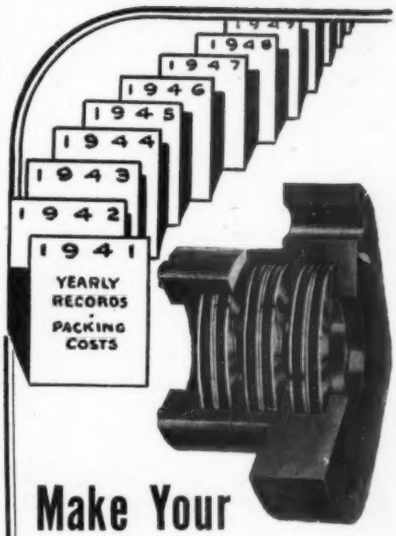
Joe H. Eustice of W. C. Norris, Manufacturer, Inc., Tulsa, Oklahoma, has been promoted to general manager in charge of operations. Eustice, who entered the employ of the firm in 1911, has held various positions of responsibility with the firm and in 1925 was named sales manager.

J. H. EUSTICE

RAY SEXTON

Ray Sexton has been placed in charge of sales administration, stepping up to this post from the position of assistant sales manager. Sexton has been with the firm for 17 years during which time he gained wide experience.

WANTED: PETROLEUM ENGINEERING GRADUATE WITH OIL FIELD PRODUCTION EXPERIENCE, by established Secondary Recovery Consulting firm. Reply by letter giving education, complete oil field experience, draft status, snapshot and salary expected. Box 8, The Petroleum Engineer, Allen Building, Dallas, Texas.



Make Your Next Packing Job *L-A-S-T!*

During these days of increased production, it is especially annoying and costly to experience shutdowns due to packing trouble.

There is a solution. Install France "Full-floating" Metal Packing in your engines, pumps and compressors. The result is increased efficiency. And each job lasts for years without maintenance expense. Saves money, too, in the long run.

Installation is a simple procedure. See that the rings are installed as lettered to correspond with similar letters on the case. As simple as A-B-C. Write for details and Catalog M-3. Make your next packing job L-A-S-T!

ORIGINAL FRANCE METAL PACKING
Sold on approval
Satisfaction Guaranteed

THE FRANCE PACKING COMPANY
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Mid-Continent Representative:
Mr. J. M. FULLER, 3725 West 7th Street
FORT WORTH, TEXAS

Original **FRANCE METAL PACKING**

Frick-Reid Changes

A number of changes in Frick-Reid Supply Corporation's organization have recently been made to permit a more direct service to the oil and gas industries on Jones and Laughlin oil country tubular goods, it is announced.

R. J. Woods, Jr., formerly district sales manager, Jones and Laughlin Steel Corporation, Tulsa, has been appointed manager of tube sales for Frick-Reid in the Mid-Continent area, with headquarters in Tulsa.

Henry J. McAdams, formerly tube salesman for Jones and Laughlin in New York City, has been appointed manager of Frick-Reid's New York office. O. P. Watkins, formerly tube salesman for Jones and Laughlin in Illinois, has been appointed to the same position with Frick-Reid in the Michigan district.

In the Gulf Coast area, T. L. (Dick) Lewis, who has been active in tubular goods sales for many years, has joined the Frick-Reid organization as district manager of tube sales with headquarters in Houston, Texas. G. E. Tyson and J. T. Batchelor have been transferred from the Jones and Laughlin organization to the Frick-Reid organization in Houston and appointed to the positions of salesman and chief clerk, respectively. F. D. Winslow, district sales manager for Jones and Laughlin at Houston, continues in charge of that territory on sales of mill products other than oil country tubular goods.

Elder Joins McKee

Arthur G. McKee and Company, Cleveland, Ohio, designing and construction engineers in the petroleum refinery and iron and steel industries, announced the appointment of Thomas G. Elder as an engineering executive in its petroleum refining division.

Elder comes to the McKee company with more than 25 years of continuous experience in petroleum refining operations. During the last three years, he was superintendent of manufacturing for The National Refining Company, in which position, besides directing all manufacturing operations, he also handled the building of new aviation gasoline facilities for National in Coffeyville, Kansas.

Joins O-C-T Staff

According to an announcement by Oil Center Tool Company, Houston, Texas, Ace Elliott has recently joined the sales staff of that company. Elliott is widely known throughout the Gulf Coast where he has been engaged in oil well and oil field equipment sales work for the last 14 years.

ACE ELLIOTT

Hanlon-Waters' Officers

M. F. Waters, president of Hanlon-Waters, Inc., Tulsa, Oklahoma, announced that at the annual meeting of the company, Edward F. Deacon, president of Climax Engineering Company, Clinton, Iowa, and the McAlear Manufacturing Company, Chicago, Owen L. Coon, chairman of the board of General Finance Corporation, Chicago, and James E. Allison, attorney for the Hanlon interests, were elected to the board.

The old officers of the company, consisting of E. I. Hanlon, chairman of the board of directors, M. F. Waters, president, and J. H. Boyle, treasurer, were re-elected. J. E. Allison, attorney for the Hanlon companies, was elected secretary. L. J. Griffey, who has been chief engineer of Hanlon-Waters, Inc., for 10 years, was made vice president, and C. W. Snyder, chief engineer.

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AS THE NAME THEY BEAR
AMERICAN
RADIAL
ROLLER BEARINGS
Engineered specifically for extra heavy duty applications where the load is radial, AMERICAN RADIAL ROLLER BEARINGS function smoothly and dependably under the most exacting service conditions. Specialized construction, flawless materials and precision manufacturing, set them apart as the most dependable bearing yet designed for radial loads where strains are greater . . . where toughness, super-strength and smooth, continuous, trouble-free performance are absolute requisites.
AMERICAN RADIAL ROLLER BEARINGS are made in five styles, 4 S.A.E. series and 85 sizes. Special designs to order are also available. Write for complete data or send us your requirements for analysis and recommendations.
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ROLLER BEARINGS
HEAVY DUTY
E-80
AMERICAN
Heavy-Duty ROLLER BEARINGS

MEETINGS

Western Petroleum Refiners Association, Annual Meeting—March 28, Jefferson Hotel, St. Louis, Missouri.

Interstate Oil Compact Commission, Quarterly Meeting—April 3 and 4, New Orleans, Louisiana.

California Natural Gasoline Association, Monthly Meeting—April 6, Rio Hondo Golf Club, Downey, California.

National Association of Corrosion Engineers—April 10, 11, and 12, Rice Hotel, Houston, Texas.

Natural Gasoline Association of America, Annual Meeting—April 12, 13, and 14, Baker Hotel, Dallas, Texas.

American Petroleum Institute, Eastern District, Division of Production—April 13 and 14, Deshler-Wallick Hotel, Columbus, Ohio.

American Society of Mechanical Engineers, Semi-Annual Meeting—April 19, 20, 21, and 22, Pittsburgh, Pennsylvania.

National Petroleum Association, Semi-Annual Meeting—April 20 and 21, Hotel Cleveland, Cleveland, Ohio.

Petroleum Industry Electrical Association and the Petroleum Electric Supply Association—Last week in April, Dallas, Texas.

American Institute of Mining and Metallurgical Engineers, Petroleum Division—May 8, 9, and 10, Rice Hotel, Houston, Texas.

American Society of Mechanical Engineers, Oil and Gas Power Division, Annual Meeting—May 8, 9, and 10, Mayo Hotel, Tulsa, Oklahoma.

American Petroleum Institute, Mid-Continent District, Division of Production—May 25 and 26, Mayo Hotel, Tulsa, Oklahoma.

Southwestern Gas Measurement Short Course—June 6, 7, and 8, Norman, Oklahoma.

American Petroleum Institute, Southwestern District, Divison of Production—June 13 and 14, Rice Hotel, Houston, Texas.

American Society for Testing Materials, Annual Meeting—June 26, 27, 28, 29, and 30, Waldorf-Astoria Hotel, New York, N. Y.

American Society of Mechanical Engineers, Fall Meeting—October 2, 3, 4, and 5, Cincinnati, Ohio.

American Petroleum Institute, Annual Meeting—November 13, 14, 15, and 16, Stevens Hotel, Chicago, Illinois.

American Association of Oilwell Drilling Contractors, 1944 Meeting—Fort Worth, Texas, date to be announced.

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FASTENINGS
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STUDS AND BOLTS
Heat and corrosion resisting metals and high strength alloy steels.
Alloy steel studs and bolts for high pressure piping stocked for immediate shipment.
Let us quote on your requirements.
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How ROCKFORD CLUTCH Design Relieves Back Plate Strain
The ROCKFORD Over Center CLUTCH has a spring steel adjusting ring plate which yields slightly as the roller cams go over center thus relieving the back plate of strains. It introduces a spring-loaded effect while holding the clutch firmly in engagement and maintaining evenly distributed pressure. . Its hard surface and freedom to float practically eliminate wear. The adjusting ring is relieved to permit slight yielding of the plate. It is threaded for accurate, easy adjustment. Let our engineers show you how this and other advantages of ROCKFORD Over Center CLUTCHES will benefit your new or improved products.
SEND FOR THESE HANDY BULLETINS ON POWER TRANSMISSION CONTROL
They tell and show how ROCKFORD CLUTCH and POWER TAKE-OFF applications are saving time, power and money in oil field equipment and a wide variety of industries. Give capacities, dimensions and specifications.
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Earth Movers
Service-Machinery
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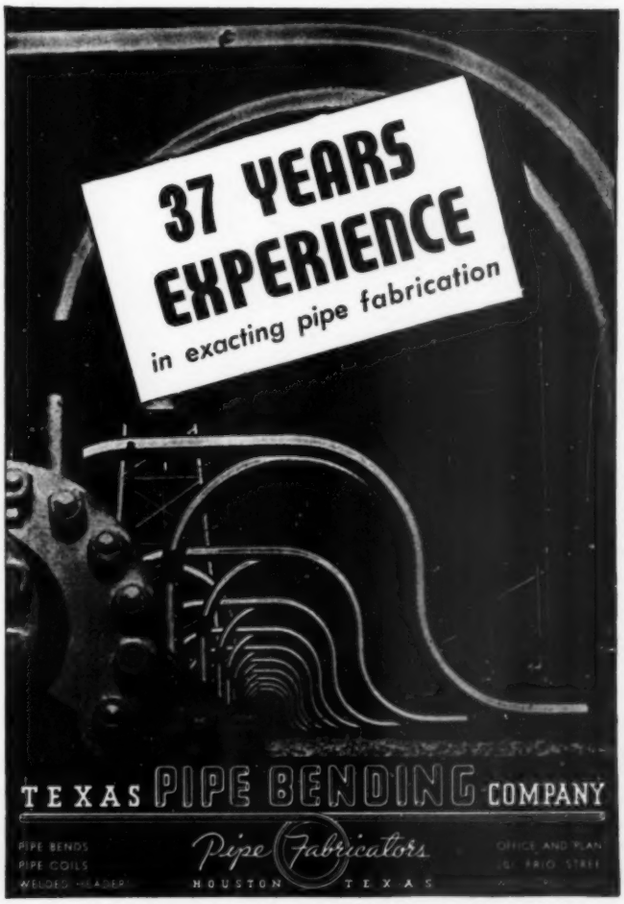
Fullmore Multiple-Disc Clutches • Over-Center and Spring-Loaded Clutches • Power Take-Offs



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AND SAFER

The Justrite Twin-Bulb Safety Lantern transforms the darkest nights to day wherever brilliant light is required. Easily carried by swinging handle. Movable steel guard serves as stand for lantern. Approved by Underwriters' Laboratories, Inc. for safe use in Class 1, Group D locations.

See your jobber for details and prices.

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2049 N. Southport Ave., Chicago, Ill.

The Justrite Twin-Bulb Safety Lantern provides powerful 634 candlepower beam. Twin bulbs guard against hazards of light failure. Rugged construction . . . can take hard knocks.

JUSTRITE *Safety Products*

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GET RID OF TROUBLE

Honan-Crane lube oil purifiers and fuel oil purifiers will provide constant protection for either gas or diesel engines.

The saving in oil and reduced maintenance work will more than pay for the original equipment.

Better engine operation and uninterrupted service are a *clear gain*. Write today for bulletins and complete information.

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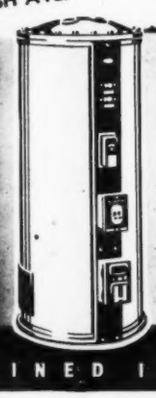

STREAMLINED IN DESIGN

TRADE LITERATURE

What to Write For

ABRASIVE MILLING is the subject covered by the new streamlined "Horizontal" catalog just announced by Andrew C. Campbell Division, American Chain and Cable Company, Inc., Bridgeport 2, Conn. The book is a handy reference volume for production men, purchasing men, and engineers who wanted to keep posted on abrasive cutting developments.

ELGIN SOFTENER CORPORATION, Elgin, Illinois, has published a new 16-page bulletin No. 603 on zeolite water softeners and other water conditioning equipment. Helpful descriptions and pictures explain the newest type zeolite softeners and how to increase the efficiency of existing softeners.

BULLETIN 1100, describing Adjust-o-Feeders, has been issued by %Proportioneers, Inc.%, well known manufacturers of equipment for continuous automatic proportioning of fluids. Illustrations, flow diagrams, and complete details of dimensions and capacities of Adjust-o-Feeder pumps make this bulletin a valuable aid in selecting pumps for specified requirements. Request for copies should be sent to %Proportioneers, Inc.%, Providence 1, Rhode Island.

READING-PRATT & CADY DIVISION of the American Chain and Cable Company has made available upon request a valve selection chart. It is on cardboard for handy reference and is ideal for shop training or for a refresher on valves. Address requests for copies to the company at Bridgeport, Connecticut.

THE DOUBLE SEAL PISTON RING HANDBOOK FOR ENGINEERS has been published to point out how money can be saved on the operation of diesel and gas engines through piston ring selection. Copies are obtainable from Double Seal Ring Company, Box 506-E, Fort Worth 1, Texas.

"APPLICATION OF MAGNETIC METHOD OF DEFLECTING TOOL ORIENTATION" is the title of a pamphlet that will be sent free upon request to Sperry-Sun Well Surveying Company, Philadelphia, Pennsylvania; Houston, Texas, or Long Beach, California. The material deals with an accurate, reliable, and speedy method of orienting drilling tools underground.

Opens District Office

Republic Supply Company announces the opening of a new district office at 624 Lake Street, Shreveport, Louisiana, with J. B. Lionberger in charge.

Lionberger is district manager of the territory comprising Shreveport, Rodessa, and Lisbon, Louisiana; Patmos and El Dorado, Arkansas; Kilgore and Talco, Texas, and Jackson, Mississippi, which are Republic Supply Company store locations. L. C. Padden will be in charge of the Fort Worth sales office at 1825 Fair Building, Fort Worth, Texas.

Joins Hycar Staff

Roger C. Bascom has joined the technical service staff of Hycar Chemical Company and will serve New England, eastern New York State, and northern New Jersey, making headquarters in Milford, Connecticut.

NORRIS

THE SWAGED NIPPLE & BULL PLUGS
USED ROUND THE WORLD
3 Times Stronger
IN THE NORRISIZED FINISHED
W. C. NORRIS pioneered and introduced the exclusive NORRISIZING treatment that eliminates rust and corrosion. Prevents galling and seizing of threads, giving you Swaged Nipples and Bull Plugs that remain bright and new throughout their useful life. To be sure of NORRISIZED Finish, insist on only the genuine W. C. NORRIS—look for the label.

EXPERIENCE
Building Oil Tools
SINCE 1882

FOR over half a century the name W. C. NORRIS and QUALITY have been synonymous in oil tools. Through quality and dependability on the job, NORRIS Swaged Nipples and Bull Plugs have won for themselves the highest endorsement of Petroleum Engineers, Superintendents and Production Men of long experience. Made of the finest materials, forged to exact size before threading, NORRIS Swaged Nipples and Bull Plugs during process of manufacture must undergo five inspections, insuring perfect fittings. Threaded to precision standards. The exterior is a special finish known as NORRISIZING, making them impervious to corrosion at no extra cost over ordinary painted finishes. Each Swaged Nipple and Bull Plug carries a NORRIS Quality Label, showing its weight, size pipe and thread. Made from Standard, Extra Heavy and Double Extra Heavy Seamless Pipe. Be sure they're NORRIS—then you can forget them! See your supply store.

Protected in shipment by corrugated containers.

W.C. NORRIS MANUFACTURER, INC.

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West Coast Distributors:
REPUBLIC SUPPLY COMPANY OF CALIFORNIA, Los Angeles
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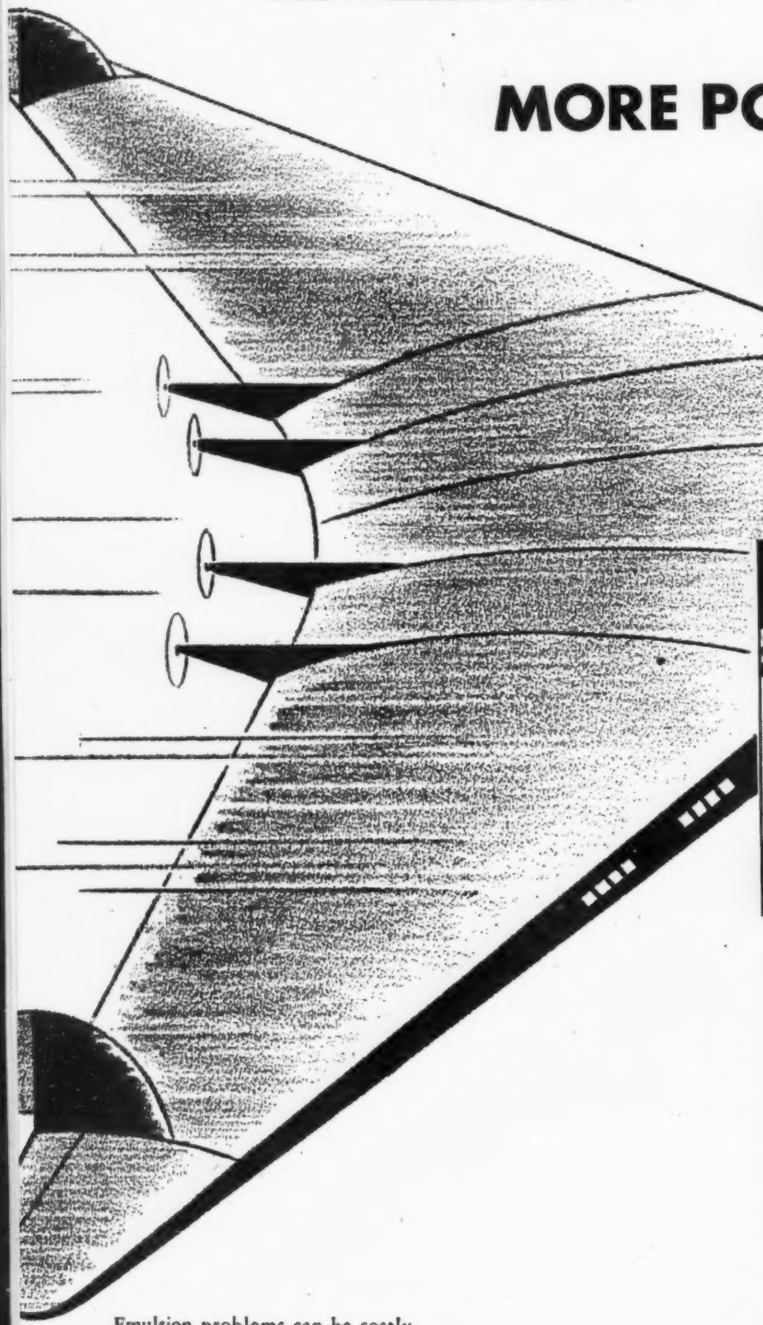
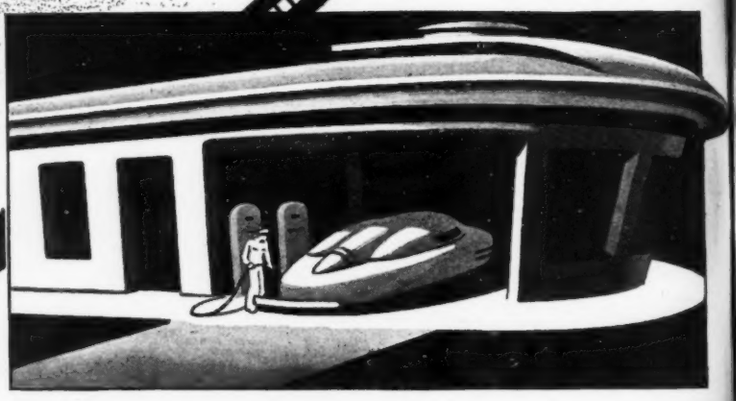
BUY WAR BONDS FOR VICTORY

A finer, more abundant living
TODAY and TOMORROW
because of Petroleum Chemistry

MORE POWERFUL · *LESS COSTLY*

MOTOR FUELS





Miracles of a new age! Man shrinks the world in size and changes its appearance! Nature supplies the working ingredients—petrochemistry, the process!

War and transportation demand more power, more speed. Oil industry answers with super motor fuels of incredible power. Fuels that double mileage and speed, lift tremendous loads and actually cost less.

Tomorrow, super fuels will power civilian planes, cars and trucks of new design, with motors a fraction of their present size. All mankind will profit immeasurably.

The world owes a debt of gratitude to oil men for such great contributions to better living. We, of Tret-O-lite, are grateful and proud to be in the service of this remarkable oil industry!

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Oil is Ammunition · Treat it Right

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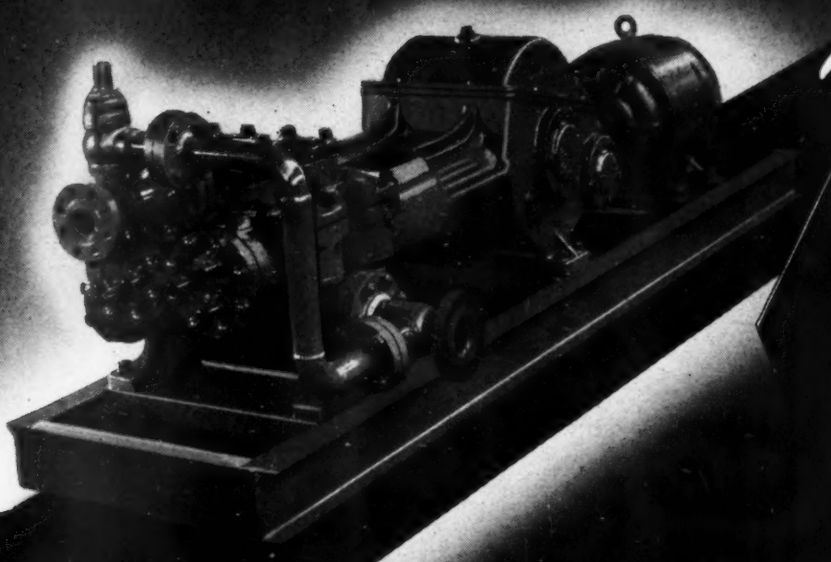
DEHYDRATING **DESALTING**

Emulsion problems can be costly unless effective treatment is given at the source. Tret-O-lite demulsification compounds have been doing the job efficiently and economically for years. And Tret-O-lite field engineers are capable and resourceful.

Complete Service for Every Field

WHEATLEY PUMPS on the "Big Inch" Pipe Line



From SUMP PUMP

(ABOVE)
2½" to 4" x 6" — DIRECT DRIVEN — FIG. No. 1324
DUPLEX — RECIPROCATING — DOUBLE ACTING
3" PISTONS — 68 B.P.H. @ 767 lbs. W.P.

To STATION STANDBY

W WHEATLEY

2½" to 4" x 6" — V-BELT DRIVEN — FIG. No. 4650
QUINTUPLEX — RECIPROCATING — DOUBLE ACTING
3½" PISTONS — 418 B.P.H. @ 765 lbs. W.P.

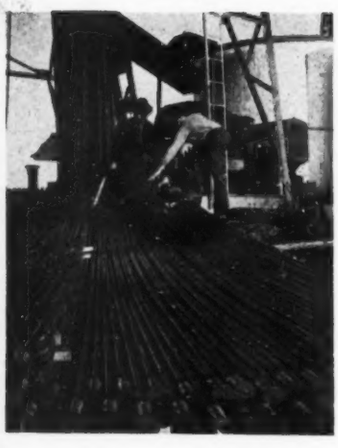
FRANK WHEATLEY PUMP & VALVE MFR.

• PIPE LINE SUPPLIES •

TULSA 6, OKLAHOMA, U.S.A.

Successor to Wheatley Bros. Pump & Valve Mfrs.

You'll never look at a better Pin End



Never, because this is the pin end of an *Axelson* Sucker Rod.

The reputation for quality is something which must be earned. That is why, during the past half century, the name Axelson has become synonymous with *Quality* wherever oil is produced.

Axelson Sucker Rods, for example, are not ordinary rods. All materials used have been developed after years of *constant* research and experiment. Laboratory and field tests have proven that the Axelson Sucker Rod pin end is correctly designed to successfully handle tough lifting jobs.

Axelson furnace and forging equipment is constructed to give complete control of rod uniformity; and frequent, rigid inspection *guarantees this uniformity.*

Internal strains in metal, resulting from partial heat treating and forging, are eliminated in huge automatic, temperature-controlled *normalizing* furnaces which treat Axelson Rods *in their entire length.*

Axelson's famous "vanishing" threads are accurately machined in true concentricity with rod body.

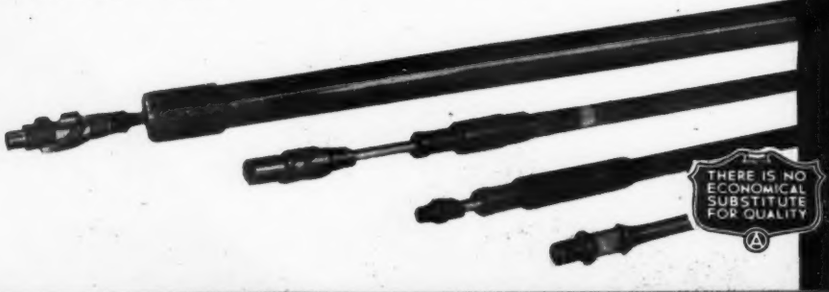
The advantage of Axelson Sucker Rod manufacturing processes is evidenced by fewer rod breaks, less "down time"; and lower production costs.

With ever deeper wells and heavier pumping loads, there can be no compromise in the quality of the sucker rods you use.

If you want *efficient, trouble-free* service, you'll never find a better sucker rod than an Axelson!

THE SUN NEVER SETS ON AXELSON PUMPS

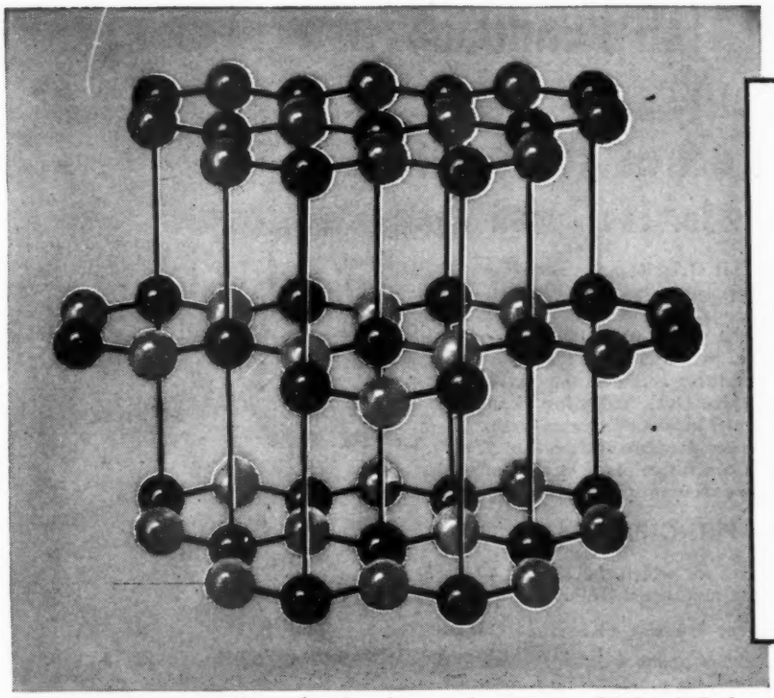
AXELSON MANUFACTURING CO.
Box 98, Vernon Station, Los Angeles 11, Calif.
50 Church St., N. Y. 7 • St. Louis 16 • Tulsa 1



AXELSON
SUCKER RODS
AND
DEEP WELL PLUNGER PUMPS

"National" Electric Furnace

GRAPHITE



Crystal Model of Graphite, showing its atomic structure. National Carbon Company research laboratories, working with the most modern X-ray spectrometry apparatus, conduct continuous studies in crystal analysis of graphite.

Pipe and Tubing • Fittings • Pumps • Valves • Brick, Slabs and Tile • Towers: Absorption, Fractionating and Scrubbing • Bubble Caps and Trays • Raschig Rings • Heat Exchangers of All Types • Bearings: Oilless Type • Ground Rods for Electrolytic Protection • Sparge Pipes • Vallez Filter Plates • Porous Carbon for Aeration and Diffusion.

TREMENDOUS GROWTH of the processing industry's uses of "National" graphite made in the electric furnace, is strikingly brought home by the above list of products.

Thorough control of graphite's extraordinary properties during manufacture... control based on years of research and experience... accounts for the increasing uses of these products. Some of the most important of such properties for the processing industry are *strength, high heat transfer, resistance to practically all corrosive liquids and vapors, freedom from contamination, wide range of porosity or imperviousness, self-lubrication, and ease of machining and fabrication.*

Some of the products listed are carbon; others "Karbate" specially treated carbon or graphite stock. However, the material used is always that which gives you the lowest processing or replacement costs consistent with the physical and chemical requirements of the application.

For detailed information, write for Catalog Section M-8000 "Industrial Applications," to National Carbon Company, Inc., Cleveland 1, Ohio, Dept. 31C.

★ BUY UNITED STATES WAR BONDS ★

The words "National" and "Karbate" are registered trade-marks of National Carbon Company, Inc.

NATIONAL CARBON COMPANY, INC.

Unit of Union Carbide and Carbon Corporation

CARBON PRODUCTS DIVISION, Cleveland 1, Ohio UCC New York, Pittsburgh, Chicago, San Francisco

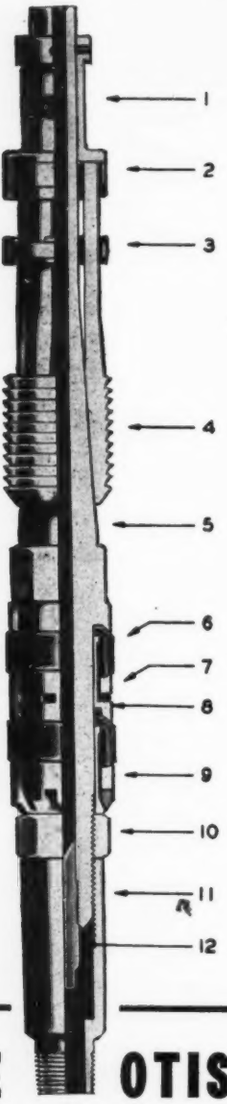
The Petroleum Engineer, published monthly, August through June, semi-monthly in July, by The Petroleum Engineer Publishing Company, seventh floor Allen Building, Dallas, Texas. Subscription price, $2.00 per year, $3.00 for 2 years, 25c a copy. Entered as second-class mail matter May 1, 1932, at the post office at Dallas, Texas, under the Act of March 3, 1879.

OTIS PRESSURE CONTROL SERVICE - EQUIPMENT

Sub-Surface Facts

No. 9 1944 DALLAS, TEX

BOTTOM HOLE CHOKING USED EXTENSIVELY FOR 5 DIFFERENT AND UNRELATED PURPOSES



THE OTIS TYPE B REMOVABLE BOTTOM HOLE CHOKE

1. *Slip Carrier*
2. *Slip Carrier Band*
3. *Mandrel Band*
4. *Slips*
5. *Mandrel*
6. *Otis Sealing Cup*
7. *Upper Sealing Cup Ring*
8. *Cup Ring Packing*
9. *Lower Sealing Cup Ring*
10. *Cup Nut*
11. *Screw Bean Cage*
12. *Screw Bean*

Versatility of Removable Type B Bottom Hole Choke Accounts for Increased Use

The Type B Otis Removable Bottom Hole Choke makes possible the plugging or choking of tubing flow at any depth in the tubing string without moving the tubing or killing the well. The tool is run and pulled under pressure on an ordinary steel measuring line with the use of a small set of tubing jars. Over 10,000 installations have been made under almost every conceivable condition of depth, temperature and pressure. This extensive use is conclusive proof of the practicability of the choke mechanism.

PRINCIPAL USE

The purposes for which the Type B Choke is most generally used are as follows:

(1) To Prevent Freezing of Surface Controls.

When the point of pressure control is moved to a sub-surface level, the tubing string is made to act as a "mile long heater" that utilizes the natural formation temperature to counteract the temperature loss due to gas expansion across the choke.

(2) To Reduce Gas-Oil Ratios.

The use of bottom hole chokes for this purpose has been very successful in wells having fluid levels that stand a reasonable distance up in the tubing string. By equipping a choke with a bean that has a capacity which is less than the capacity of the formation to produce oil, and setting this choke below the fluid level, a fluid seal may be set up that retards the entrance of free gas into the well bore.

(3) To Retard Water Encroachment.

By installing a bottom hole choke with a flow bean that gives the optimum desired rate of flow, a constant bottom hole pressure is maintained. This optimum rate of flow cannot be exceeded unless the choke is first pulled from the well. This operation therefore tends to stabilize and hold consistent the water-oil contact.

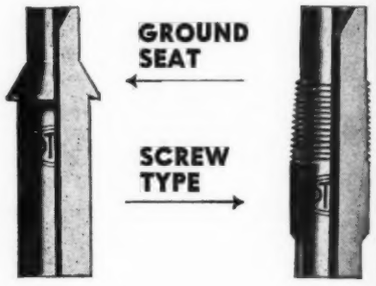
(4) To Cause Continuous Flow in Wells that Frequenty Load Up.

This practice is successful where the oil contains considerable gas in solution at the bottom of the hole. In such cases, bottom hole choking liberates the gas in the lower end of the tubing string, thereby causing the oil column in the tubing to be greatly lightened. Many wells which otherwise frequently load up have by this practice been made to flow steadily for months.

(5) To Plug Tubing.

The Type B Choke equipped with a blank ground seat bean is used extensively to plug tubing so that tubing connections can be changed or tubing pulled under pressure.

TWO TYPES OF BEANS USED ON BOTTOM HOLE CHOKE



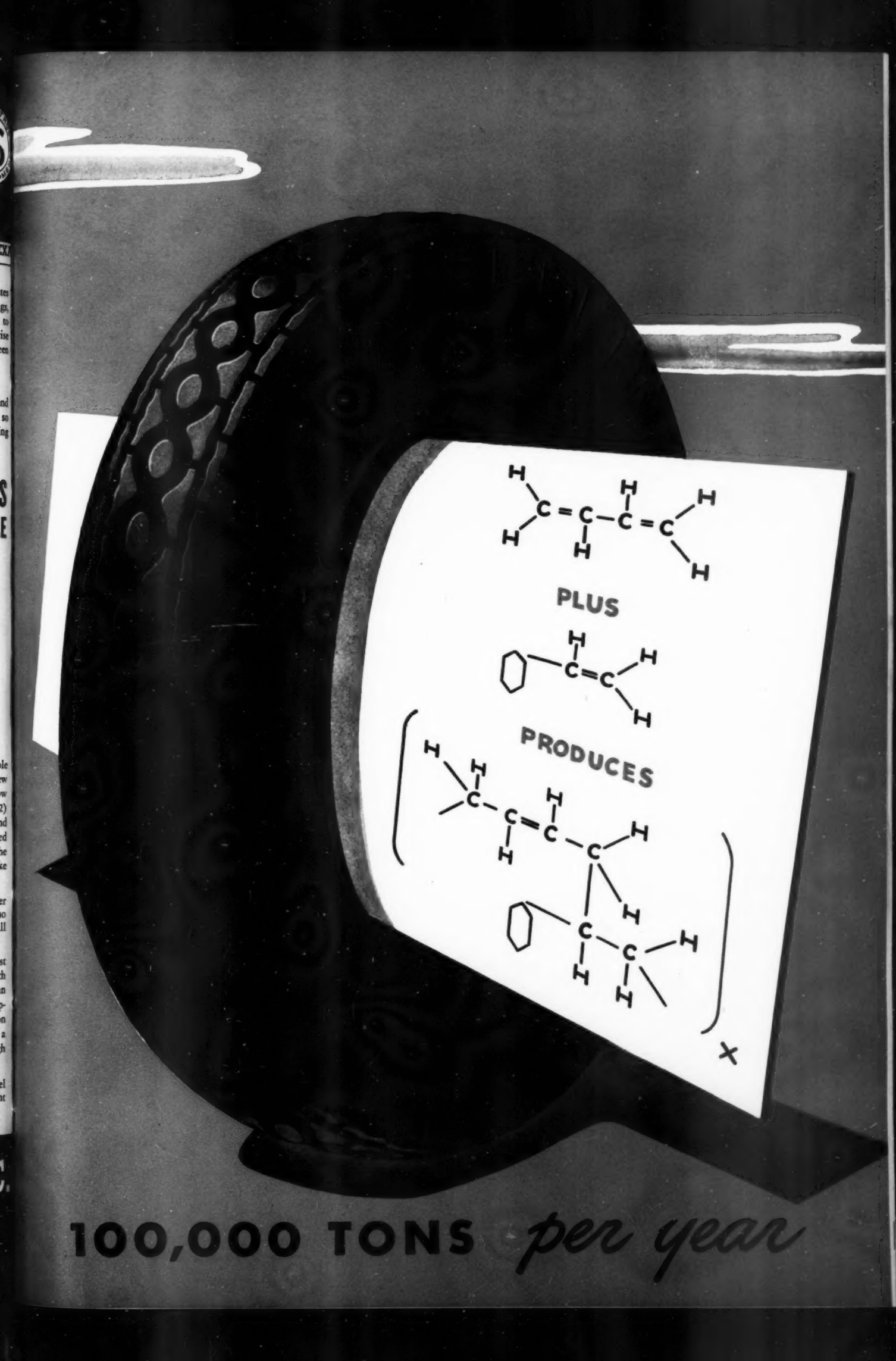
The Type B Otis Removable Bottom Hole Choke utilizes either a Ground Seat or a Screw Type positive choke bean to control rate of flow through the tubing. The bean (Screw Bean, 12) and Bean Cage (11) are attached to the lower end of the Type B Mandrel Assembly. A perforated nipple may be attached to the lower end of the Bean Cage to act as a screen to prevent the choke bean from becoming plugged.

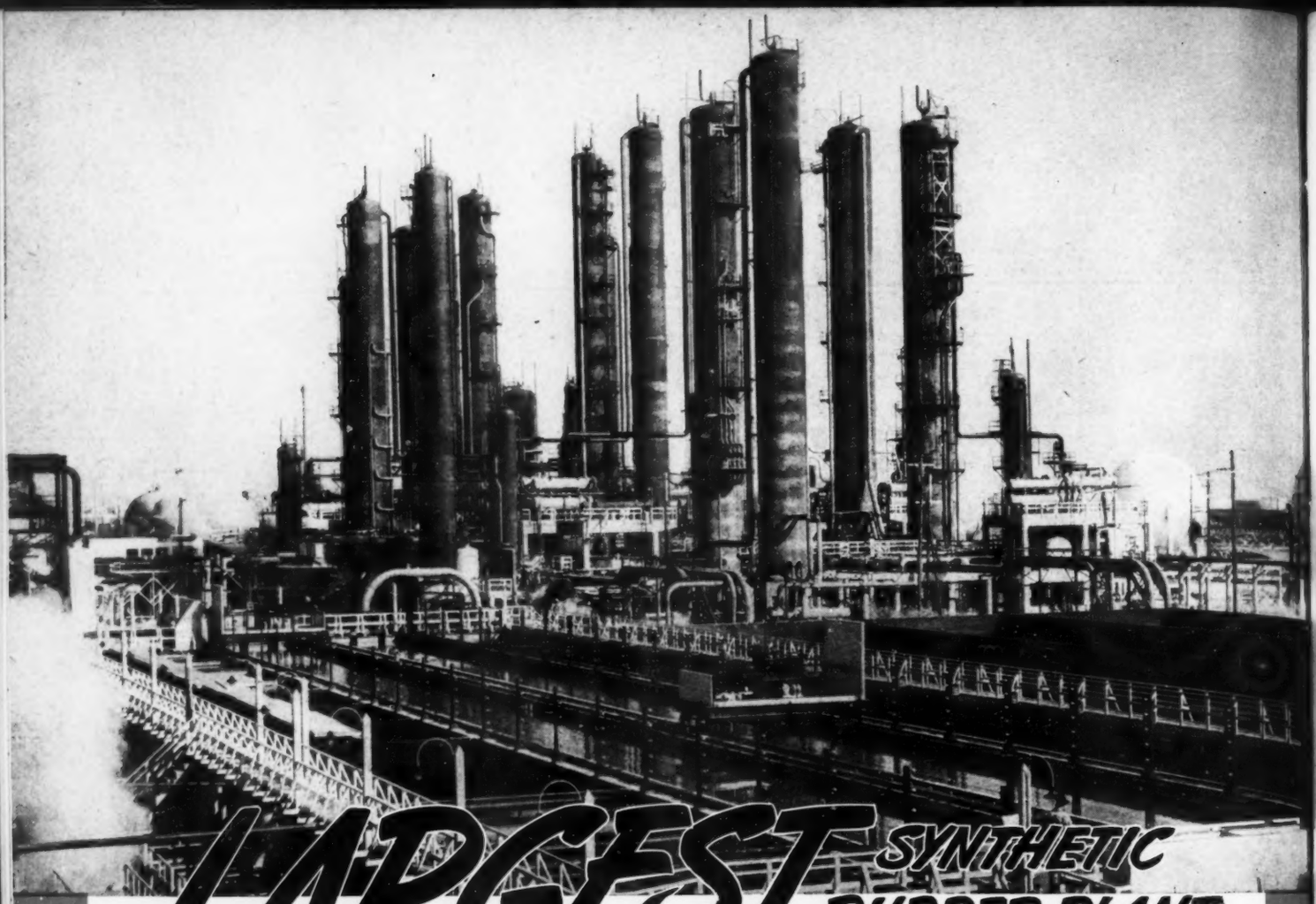
The Screw Type Bean is threaded into the lower end of the mandrel and is used when little or no fluid is above set choke level. It is also used in all high pressure installations.

The Ground Seat Bean is held in seat against lower end of the mandrel by a bean spring which is compressed between the shoulder on the bean and the bean cage. This type bean permits pumping down through the choke. A prong used on the pulling tool will unseat the bean, providing a by-pass to facilitate pulling the choke through liquid.

These beans are made of heat-treated K-Monel which has proved to be the metal most resistant to the abrasive and corrosive action of flow.

OTIS PRESSURE CONTROL, INC.
DALLAS, TEXAS


PLUS
PRODUCES
x
100,000 TONS per year



LARGEST SYNTHETIC RUBBER PLANT in the world!

Neches Butane Products Company, designed and built by The Lummus Company for the production of ***100,000 tons of butadiene per year,*** is managed by Gulf Oil Corporation, The Texas Company, Socony-Vacuum Oil Company, Inc., The Pure Oil Company, and Atlantic Refining Company.

A technical committee, composed of members from eight major oil companies and Lummus, investigated all butadiene process developments and selected the process steps used. Difficult and new distillation problems due to the magnitude of the operation and the complexity and exacting nature of the process steps were solved in light hydro carbon separations and purification. A measure of the magnitude of the project is shown in the utilities system including a feed water treating system and boiler plant for 2,200,000 pounds per hour of high pressure steam and a cooling water system of 225,000 gallons per minute circulation. The fabrication and delivery of 72 large bubble towers, some of them 14 ft. diameter and 160 ft. high, were accomplished by construction of a shop on the site equipped with modern handling facilities and automatic welding and forming equipment.

The petroleum chemical industry in its growth will require a solution of many new difficult and complex problems similar to those encountered in the development of the synthetic rubber industry. Lummus by its performance in butadiene, styrene, phenol, toluol and explosives has proven itself the leader in this industry.

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LUMMUS

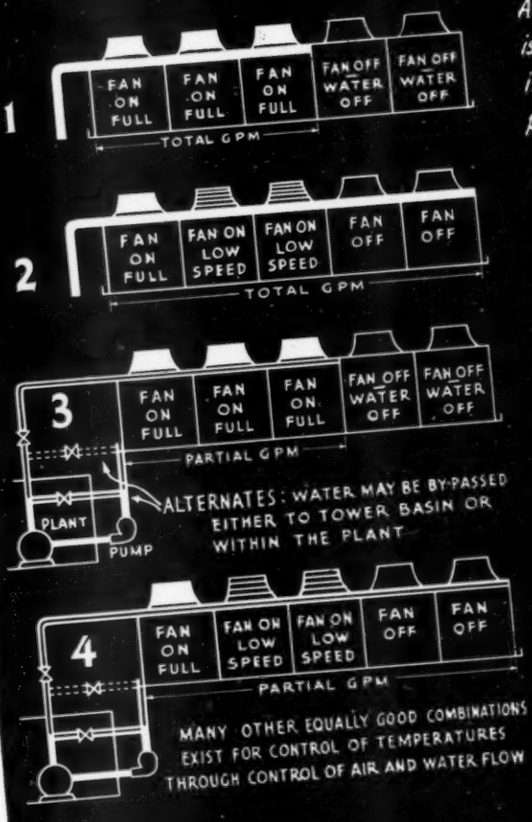
PETROLEUM REFINING PLANTS

Cooling Tower DOs and DON'Ts

-by MARLEY (No. 1 of a series)

COLD-WEATHER OPERATION

Trouble-free cold-weather operation can be had with modern cooling towers by proper control and maintenance of air and water temperatures within the tower. Water temperatures in all types of towers can be regulated by (a) utilizing only a portion of the tower, (b) by-passing some of the water, or (c) simply throttling the quantity.



Air flow, which affects internal air temperatures, is difficult to control in natural draft towers but is relatively simple with mechanical draft, particularly if fans have 2-speed motors.

To maintain required temperatures, any of these methods, or a combination, may be used:

1. *Circulate all the water over only a portion of the tower, shutting down the remainder completely.*

2. *Circulate all the water over the entire tower with all fans idle or any combination with fans at high speed, low speed or idle.*

3. *By-pass some of the water and shut down some sections of the tower completely.*

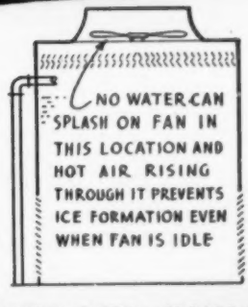
4. *By-pass some of the water and circulate the rest either over the entire tower or only some sections of it, with fans variously set at full speed, low speed or idle.*

Except in the case of poorly designed towers, good operating practice can avoid "icing" troubles. But should ice have to be removed, thaw it by raising air-and-water temperatures, preferably in one section at a time. If done with hot water or a steam hose, start at top and work down. Induced draft towers can be de-iced by leaving water run and (a) reversing fan rotation if motor and drive permit, or (b) stopping each fan and covering it.

MARLEY COOLING TOWERS

14-A

DO YOU KNOW — that Marley led in developing and advocating the induced draft tower largely because of its all-around operating advantages. Cold-weather features include: 1. Effective performance by natural draft, with fans idle. 2. Only *hot* air passes through fans, keeping them free of ice.



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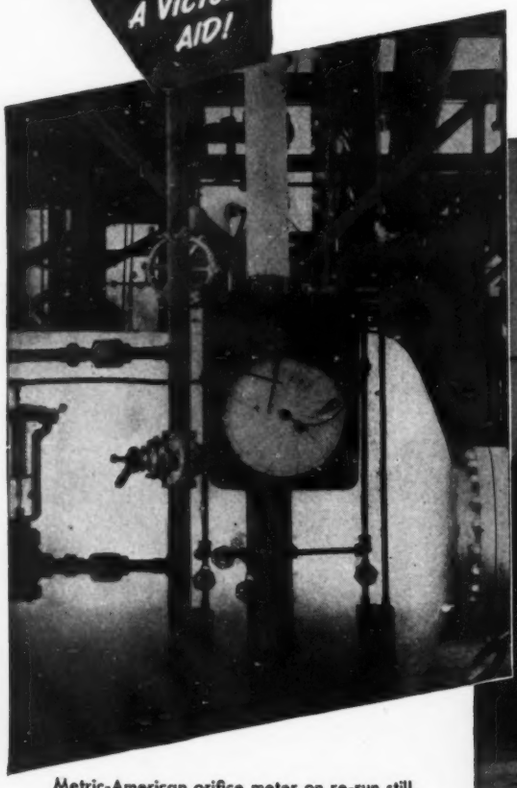
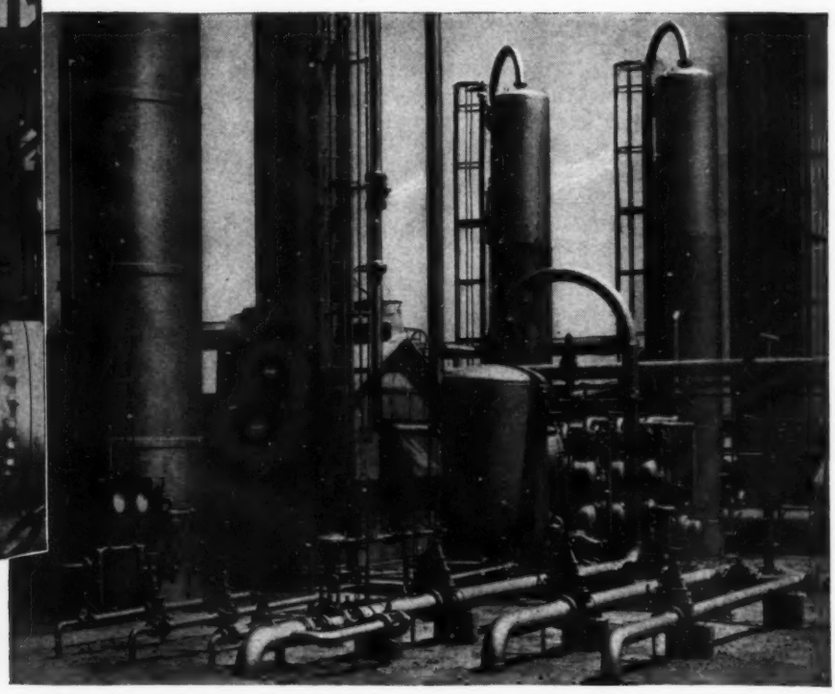
SIMPLIFICATION ★ A VICTORY AID!

Being Right the First Time!





Metric-American orifice meter on re-run still.

IN PETRO-CHEMICAL PROGRESS, pilot plant and new technology can take full advantage of proven instrument performance. Where time is precious, and new equipment at a premium, trial-and-error methods in the selection of instruments have short shrift.

During a century of steady technological advance, American Meter Company measurement instruments have pioneered first in the gas industry and then in the petroleum industry. *The long sustained accuracy of its present instruments is equal to the smallest visible reading on test gage or chart.*

Among the factors responsible for low-cost accuracy and maintenance, none has been more important than the simplicity demanded by practical engineering.

Simplified design and construction make operation dependable . . . adjustment speedy . . . cleaning easy.

Are you familiar with all the types available in Metric-American orifice meters, flowmeters and control instruments? Catalogs upon request.

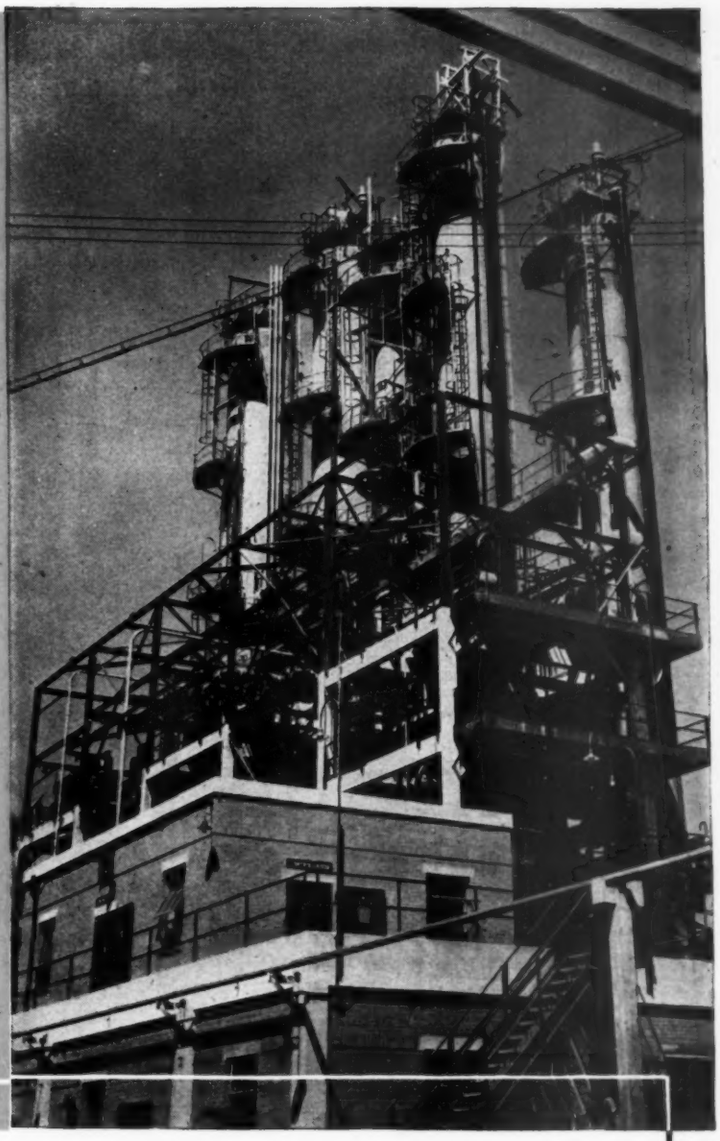
METRIC METAL WORKS • ERIE, PA.

AMERICAN METER COMPANY

INCORPORATED (ESTABLISHED 1836)

1934

REASONS for McAlear Leadership



High pressures and temperatures required for butadiene, styrene and high octane gasoline units have placed great responsibility upon control devices.

And so McAlear engineers are constantly searching for new corrosion resistant materials, new machining methods and new control mechanisms for these extreme and often critical operating conditions.

Recent developments include controls for processes involving pressures as great as 3000 pounds per square inch and temperatures as high as 1400° F.

Here a control failure can paralyze an entire plant, endangering workers' lives and vitally needed equipment and material.

No McAlear Control has failed under these exacting requirements. No McAlear Control will fail under *your* requirements.

NEW ENGINEERING DEVELOPMENTS

1 AN IMPROVED DIAPHRAGM VALVE

New materials and radically improved design provide positive freedom from difficulties formerly encountered with diaphragm type valves. Unrestricted flow to the full capacity of pipe line. Long-life, leak-proof shut-off surfaces. Completely dependable in service with highly corrosive fluids. Vastly superior where solids are held in suspension.

2 NEW, HIGH-PERFORMANCE LEVEL CONTROLS

Specifically engineered for requirements of petroleum field. No stuffing box. Wide throttling range for liquids of different specific gravities, at all operating pressures. 100% pneumatic pilot provides sensitive, precision control of motor diaphragm valve or remote level indicating instrument.

WATCH MC ALEAR FOR NEW DEVELOPMENTS!

DO YOU HAVE A CONTROL PROBLEM?

Call on McAlear engineers. Draw on their fund of experience . . . on their ability and readiness to help you. Write for helpful bulletins and catalog. McAlear Manufacturing Company, 1909 S. Western Avenue, Chicago 8.

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PRESSURE · FLOW · LIQUID LEVEL · TEMPERATURE
controls
for STEAM, WATER, AIR, OIL-GAS

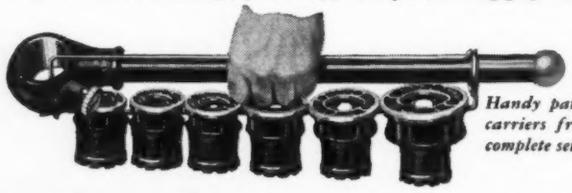
RIDGID
HOUSING
doesn't break

Handy little
THREADER
that's a big
work-saver
RIDGID
NO. 00R

So... no repairs—no repair expense—no wrenches out of use

● When you use RIDGIDs, you don't need so many spares around—for these wrenches usually last till you lose them. Ask any of the millions who use them. They'll tell you also that the full-floating hookjaw and the adjusting nut *always* work freely, never bind. The no-slip jaws, handy pipe scale on hookjaw and comfort-grip I-beam handle are also things you'll like. For economy and easier work, buy the RIDGID—at your Supply House.

● Its popularity comes from more than its popular price. For this small RIDGID Ratchet Threader, ⅛" to 1" pipe capacity, has many time-and-work saving features you like—heads that snap in from either side and lock; dies that reverse quickly for close-to-wall threading. Dies are of tool steel, accurately ground, easily removed for regrinding. Special conduit dies, if you want them. It pays to ask for No. 00Rs—also 111R, ⅛" to 1¼" at your Supply House.



Handy pat'd wire carriers free with complete sets.

Sold by Supply Houses Everywhere

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★ PIPE TOOLS ★

Millions of RIDGID Tools in use

THE RIDGE TOOL COMPANY
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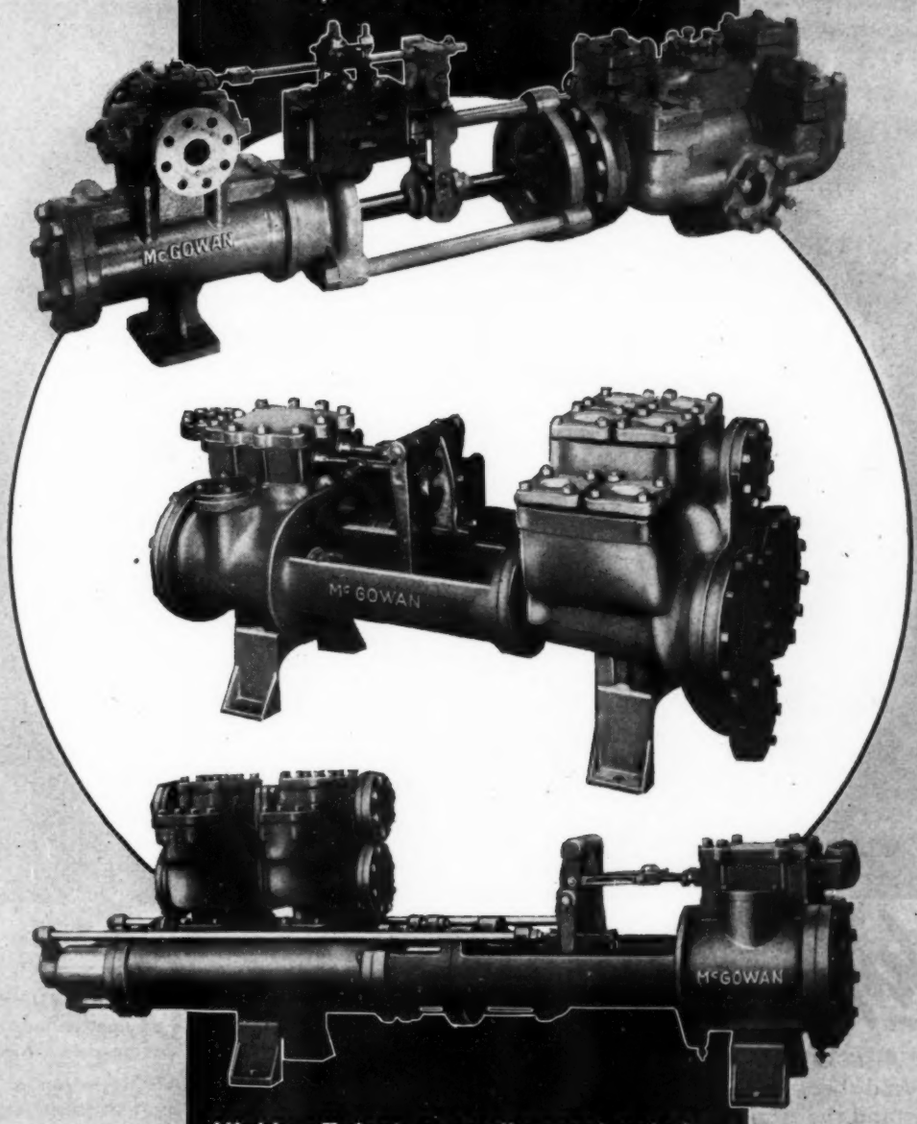
McGOWAN PUMPS *for the Petroleum Industry*

Dependable Since 1852



Highly efficient, ruggedly constructed—McGowan Pumps have the ability to stand up year in and year out under severe service conditions. An experienced Engineering Department is available for information on installations and requirements.

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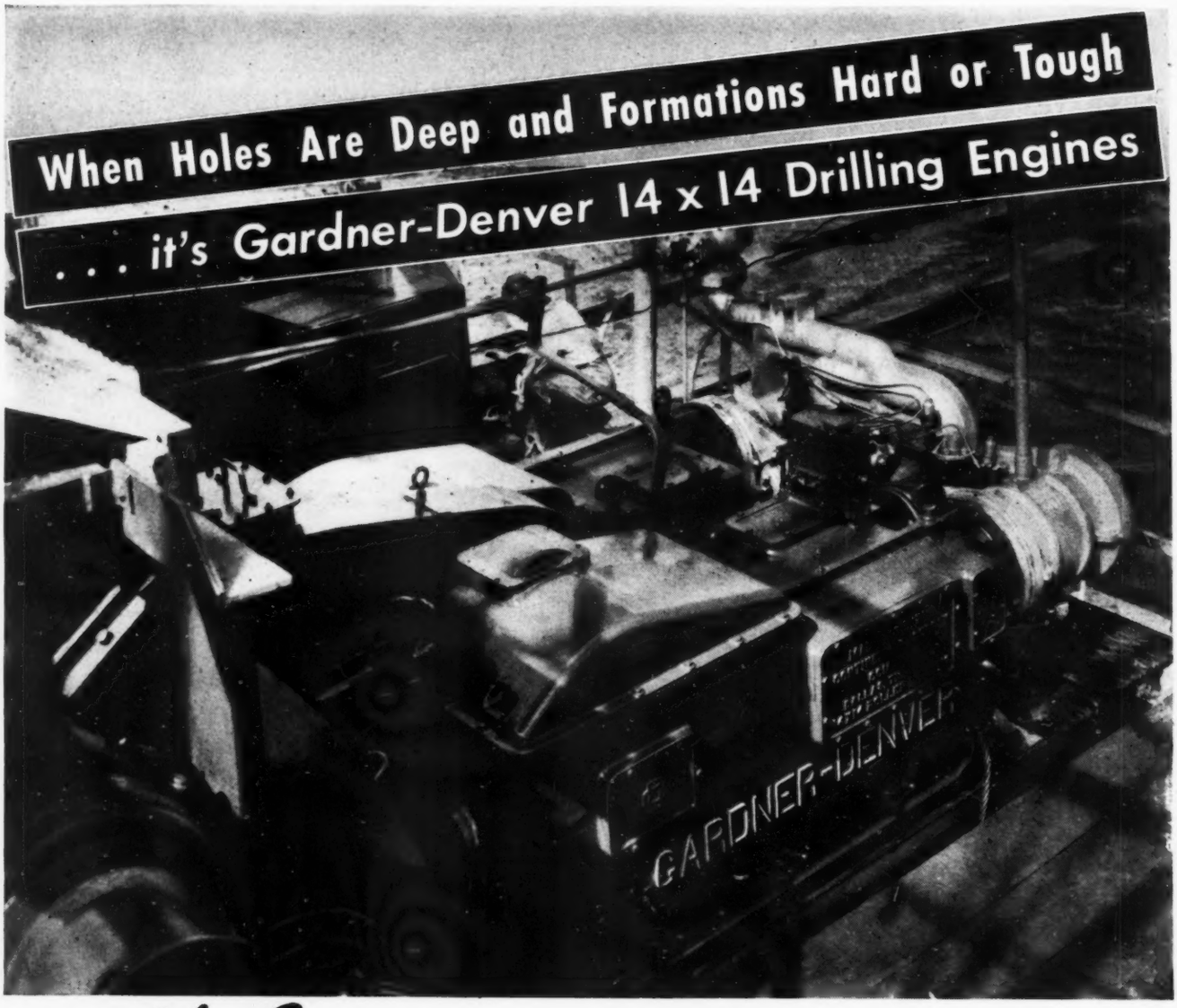
LEYMAN MANUFACTURING CORP.

The JOHN H. McGOWAN *Co.* DIVISION

59 CENTRAL AVE., CINCINNATI, OHIO

When Holes Are Deep and Formations Hard or Tough

. . . it's Gardner-Denver 14 x 14 Drilling Engines



Why? Because they have power—plenty of power to drill the deepest holes through the hardest or toughest formations.

—And because they are built "tough"—to withstand the terrific strain of modern deep well drilling.

NOTE THESE FEATURES:

- **VALVE GEAR is adjustable to suit varying power requirements—easy to operate and adjust—assures greatest steam economy.**
- **HIGH STEAM EFFICIENCY—because short and direct steam ports decrease clearance—steam cylinders are built for 400 pounds pressure per square inch.**
- **LONGER LIFE OF RINGS AND PORTS—because single eccentric valve gear gives a quick opening valve—reduces wire drawing.**
- **TOTALLY ENCLOSED ENGINE CONSTRUCTION—provides protection against water and dirt—valve driving mechanism is enclosed in main frame.**
- **AMPLE LUBRICATION—even at slowest operating speeds—assured by five-feed large capacity lubricators with diaphragm check valves that force oil to all essential bearings.**
- **FEWER MOVING PARTS—metallic packing in all stuffing boxes.**

●

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GARDNER-DENVER

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BECAUSE we are the world's largest manufacturers of wire rope, it was logical for Uncle Sam to turn to us early for help in supplying the huge tonnages of wire rope needed for the war effort. To date, American Tiger Brand Wire Rope has been used in breath-taking quantities on every front.

As new and unusual service tasks had to be faced, our engineers produced the right wire rope to meet them. Our plants were kept running around the clock. Production facilities were expanded again and again to keep pace with wartime needs.

Now a growing amount of Tiger Brand is becoming available for use here at home. This wire rope incorporates all the improvements that war-stimulated advancement in rope-making technique provides. So, when you need wire lines—and want the best—get in touch with your Tiger Brand distributor.

Excellay Preformed

AMERICAN STEEL & WIRE COMPANY
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COLUMBIA STEEL COMPANY
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United States Steel Export Company, New York

UNITED STATES STEEL

Expert Crews 2½ Miles Down On Short Cut To TOKYO

Next to drilling right on through to the seat of Tojo's kimona... the expert crews on this rig know that the shortest cut to Tokyo is the discovery of more and more oil. From it must come the fuel to power ships, aviation gasoline for the world's greatest air force, Toulene for explosives, Butadiene for rubber, and countless other necessities of modern warfare.

Day and Afternoon Drilling Crews

West Texas' Deepest Well

From Left to Right

First Row

Glen Whitman, Tool Pusher
Ben Gilliam, Tool Pusher
Chet Buzzard, Union Wire Rope Corp. Representative

Second Row

J. A. Leatherwood, Driller
Deb Herring, Roughneck
L. B. Whatley, Roughneck
G. F. Jones, Roughneck
Buck Thompson, Roughneck

Third Row

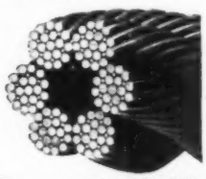
Z. E. Aldridge, Driller
C. L. Anderson, Roughneck (holding mascot-weevil hawk)
J. T. Burge, Roughneck
L. H. Long, Roughneck
Roy Lanier, Roughneck

Send For These FREE BOOKLETS

Socketing Wire Rope.. Splicing Wire Rope... Correct Handling of Wire Rope..Wire Rope Lubrication ... Rope Dope .... any one or all of them.

C-44

union-formed Wire Rope



On the Job Day and Night Since August, 1942

In this war emergency the oil industry has placed its resources fully behind replenishments of our oil reserves. For more than a year and a half, three expert drilling crews have kept this rotary rig in continuous operation. Delays have been few and minor. At the greatest depth ever reached in West Texas, they keep on making good headway.

One very good reason for this is the fact that West Texas' deepest well is being drilled with Union-formed Wire Rope. Union-formed is the name well worth remembering when you want pre-formed wire rope. It is precision-engineered and precision-made. In the full-fledged Union Wire Rope laboratory, engineers first predetermine, then check and recheck its tensile strength, torsional values, fatigue life, ductility, hardness of wires, and other characteristics which give it greater toughness and durability.

Much wire rope must still be produced to hoist, handle, load and unload vast tonnages of war materiel for our all-out invasion efforts. However, when you need preformed wire rope, SPECIFY Union-formed and save not only wire rope but steel, labor and valuable time.

UNION WIRE ROPE CORPORATION

2106 Manchester Ave., KANSAS CITY 3, MO.

Tulsa Houston Chicago Salt Lake City
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For Two Years of Team-work with Our Armed Forces

UNION WIRE ROPE CORP.

union Wire Rope

"THE ULTIMATE IN LOW COST WIRE ROPE"

Announcement

FRICK-REID SUPPLY CORPORATION has been appointed exclusive distributor of **JONES & LAUGHLIN** oil country tubular goods in the territory east of the Rocky Mountains in the U. S. A.

Consolidation of offices in the oil and gas country with its parent company, **JONES & LAUGHLIN STEEL CORPORATION**, permits a unified service to the oil, gas and industrial trade.

FRICK-REID SUPPLY CORPORATION, which exclusively serves the oil and gas industries through its 61 branch stores and 19 district and sales offices, is now able to give the same direct service on oil country tubular goods as it is now giving on the general line of equipment and supplies, process engineering and construction.

JONES & LAUGHLIN STEEL CORPORATION district offices in the oil and gas country are now in position to give an exclusive service on all other mill products to their industrial trade.

FRICK-REID SUPPLY CORPORATION

Subsidiary of

JONES & LAUGHLIN STEEL CORPORATION

General Office: TULSA, OKLAHOMA

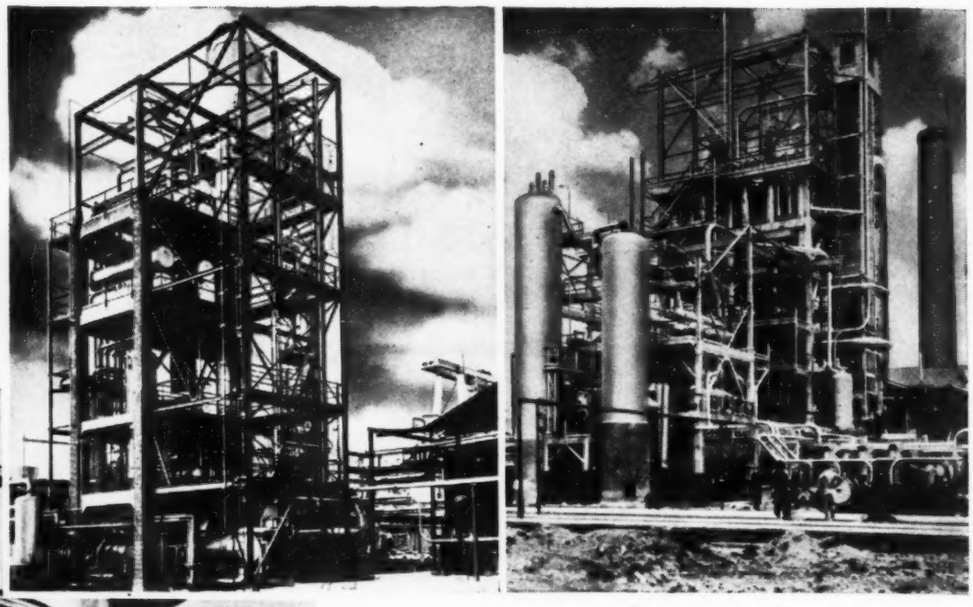
Distrct and Sales Offices: Houston, San Antonio, Odessa, Wichita Falls, Fort Worth, Dallas, and Longview, Texas; Bartlesville and Wewoka, Oklahoma; Hutchinson, Kansas; New Orleans, Louisiana; Mt. Vernon, and Chicago, Illinois; Cody, Wyoming (effective March 1, 1944); Mt. Pleasant, Michigan; Pittsburgh and Bradford, Pennsylvania; New York, New York; Washington, D. C.

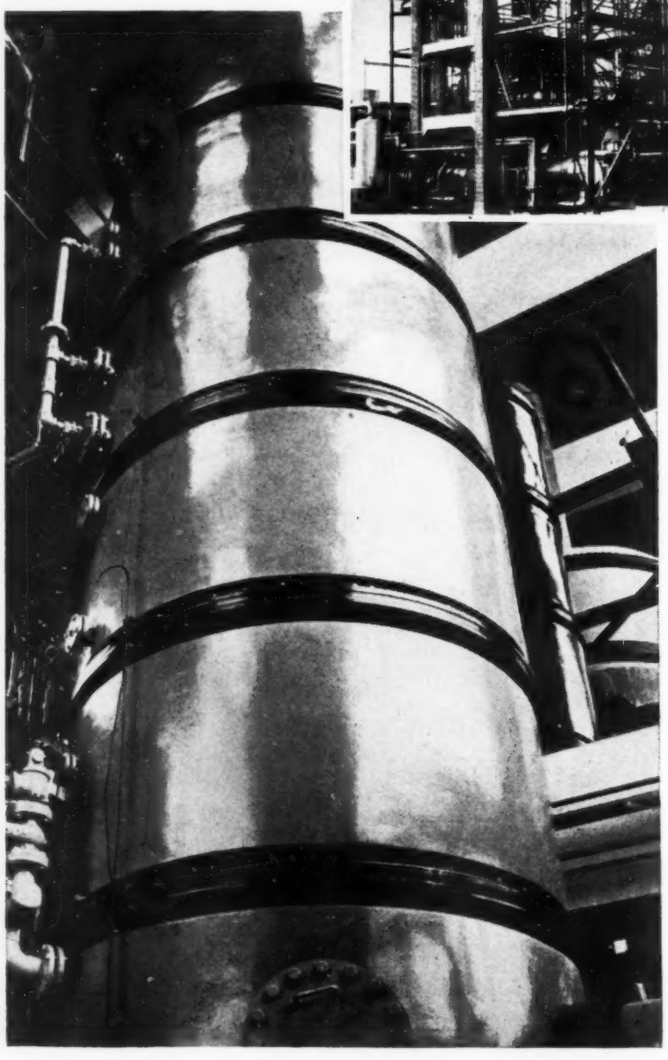
One Answer to the Costly Corrosion Problem

Stainless steel cracking tubes for this refinery unit (near right) resist corrosion, embrittlement, and creep at high temperatures. (Courtesy, The Lummus Co.)

•

Bubble tower (far right) for producing high octane gasoline is lined with 12 to 14 per cent chromium steel to resist hydrogen sulphide corrosion. (Courtesy, The Lummus Co.)





Distillation columns of stainless steel used in the synthetic rubber industry resist the corrosive effect of chemicals and also insure the purity of the chemicals for the synthesis of rubber.

LABORATORY and field tests show that in general the corrosion resistance of steel equipment increases with increasing chromium content.

Stainless steels contain at least 12 per cent chromium. These withstand corrosion from brackish condenser water, and from hot petroleum products that contain sulphur compounds. They resist oxidation by furnace gases, even when under heavy stress. They retain high strength at elevated temperatures. They are wear-resistant.

Because of these properties stainless steels have many applications in the petroleum industry: in tubes of heat exchangers; in high-temperature air preheaters on stills; in flue-gas recirculation systems; in systems removing hydrogen sulphide and mercaptans; in pumps, liners, orifice plates, thermocouple wells, baffles; in furnace tubes and dampers.

Corrosion resistance—heat resistance—wear resistance—these advantages of stainless steels, so important to petroleum equipment, can be utilized in many other fields. Stainless steels have a unique service record in the tough jobs of industry.

We do not make stainless steel, but we do make ferro-chromium—the backbone of stainless steel. For more than 35 years our metallurgists have studied ferro-alloys and alloy steels in the laboratory and in the field. If you have a question on the selection or use of stainless steel, consult us.

BUY UNITED STATES WAR BONDS AND STAMPS

ELECTRO METALLURGICAL COMPANY
Unit of Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York 17, N. Y.
In Canada: Electro Metallurgical Company of Canada, Limited, Welland, Ontario

Electromet
Trade-Mark
Ferro-Alloys & Metals

Advantages of
STURDYBILT
Prefabricated Houses

- Flexibility of Design
- Movability
- Time Saved
- Material Saved
- High Salvage
- Low First Cost
- Low Maintenance

● *Regardless of the size or style of the finished structure, the STURDYBILT 4′ x 8′ wall section, complete when it leaves our mill, is the base of construction. These sections are large enough to allow economical fabrication and small enough to permit rapid erection.*

WHEN the oil industry calls for economical buildings in a hurry . . . STURDYBILT houses are the answer.

STURDYBILT prefabricated houses are precision-built by modern line construction methods, in Southern Mill plants. Floors, ceilings, roofs, and walls are built in standardized sections which are easily transported from factory to site. The time required for erection of STURDYBILT houses is figured in hours instead of days, and semi-skilled or unskilled labor can be used to do the job.

No matter what type unit is required, STURDYBILT standardized sections can be made into a building of almost any size and shape. Send us floor plans of the kind of buildings you require, and we will show you how STURDYBILT prefabricated buildings can be adapted to your specifications . . . quickly and economically.

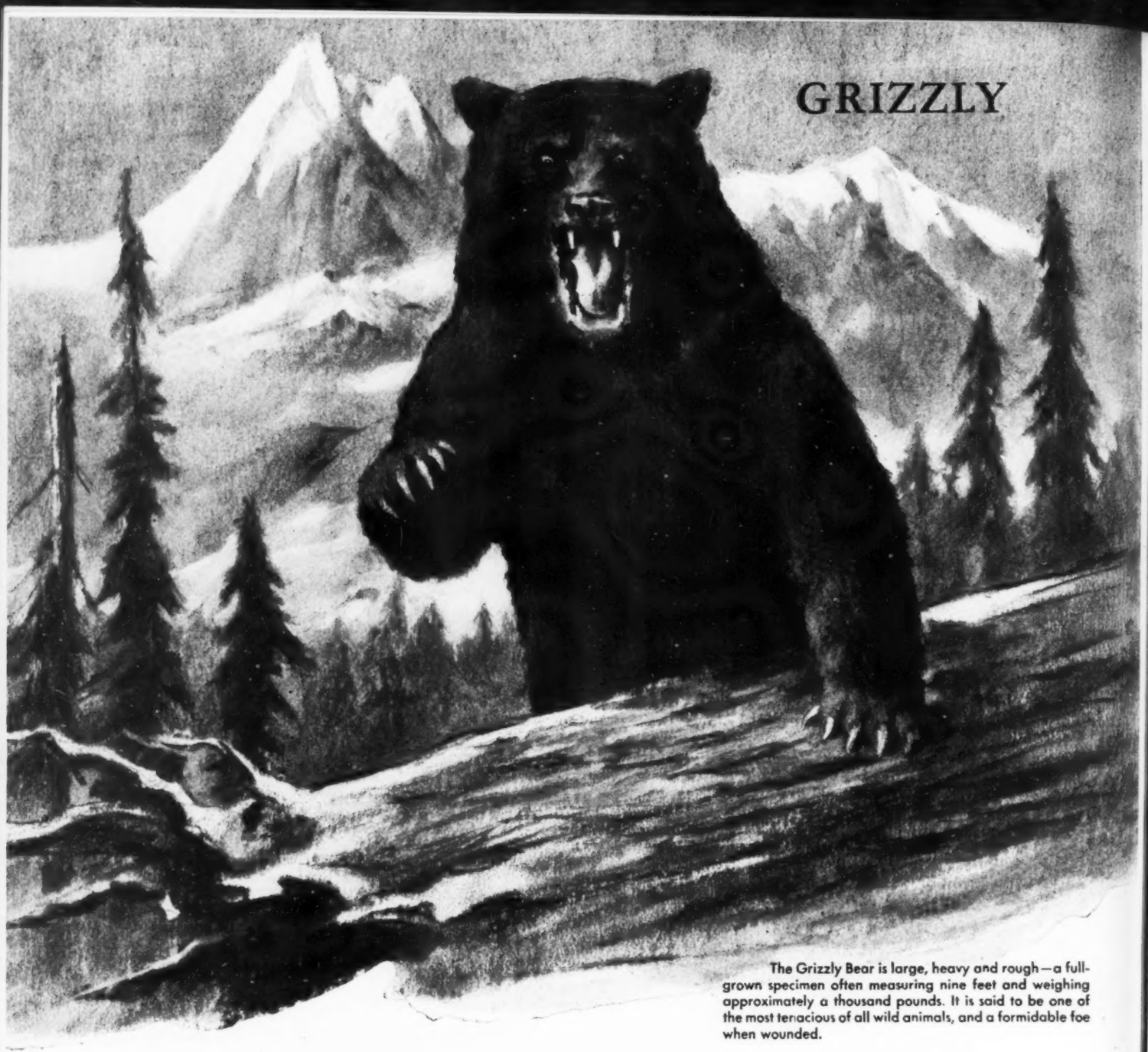
When SPEED is essential . . . depend on STURDYBILT!

Manufacturers of Special Millwork; Distributors of Johns-Manville Insulation, Roofing and Siding Shingles; Curtis Factory-built Woodwork.

LEASE HOUSES ● BUNK HOUSES ● PIPELINE CAMPS and STATIONS
WAREHOUSES ● GARAGES ● RECREATION HALLS ● TOOL HOUSES

SOUTHERN MILL & MANUFACTURING CO.

Wichita, Kansas **TULSA, OKLAHOMA** Longview, Texas



The Grizzly Bear is large, heavy and rough—a full-grown specimen often measuring nine feet and weighing approximately a thousand pounds. It is said to be one of the most tenacious of all wild animals, and a formidable foe when wounded.

WHY GRIZZLY DRILLS MORE FOOTAGE

---and More Wells

GRIZZLY Pressure-Seal ROTARY HOSE

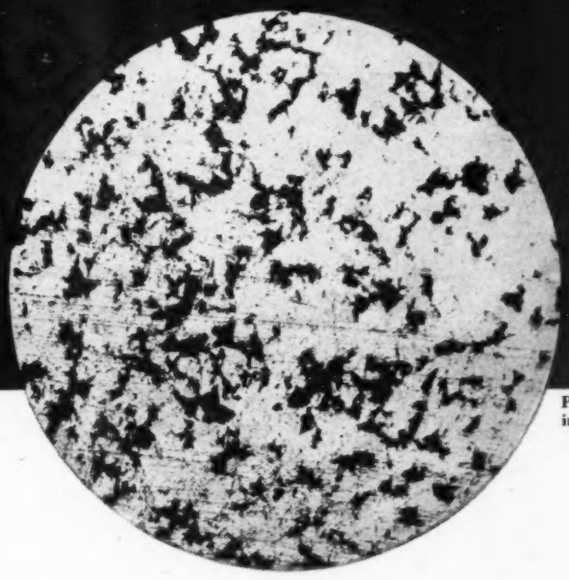
A 50-foot length of Grizzly Hose snaked out on warehouse floor, illustrating its exceptional flexibility.
PRESSURE SEAL
3 GRIZZLY POWERFLEX

Grizzly couplings *cannot pull out or blow out*... There are *no nipples to cut out*... The hose is steel-armored and full-flow *throughout its entire length*... All these advantages are due to the exclusive Grizzly pressure-seal and steel-armored features—genuinely important developments in rotary hose design and construction which insure drilling the maximum footage and number of wells.

GRIZZLY MANUFACTURING COMPANY
(Formerly E. M. Smith Company)
MANUFACTURING PLANTS: LOS ANGELES, CALIFORNIA AND PAULDING, OHIO
Complete Warehouse Stocks Maintained At:
Houston, Texas • Oklahoma City, Oklahoma • Casper, Wyoming
Export: The Continental Supply Co. Inc., New York, N. Y.

PORUS-KROME*

...bristling with tiny pools of oil



Photomicrograph of PORUS-KROME (100X) showing hundreds of tiny pockets in the surface.

Thorough "wetting" of the hard chromium in PORUS-KROME is brought about by the tiny pools of oil retained in the pores or pockets in the surface. The 100X photomicrograph shows these pockets in black and the pure chromium, which has been honed, is the light area.

This form of chromium, resistant to both corrosion and abrasion, and so well lubricated, makes PORUS-KROME the best treatment for cylinder walls and other bearing surfaces. Oil consumption is maintained at a constant low level because PORUS-KROME wears so slowly. It multiplies cylinder life four to twenty times, and reduces scuffing, ring-feathering, and risk of piston seizure.

Let Van der Horst engineers show you how PORUS-KROME can improve the reliability of the engines you are planning for peacetime sales. Write today for information.

VAN DER HORST TRADE MARK

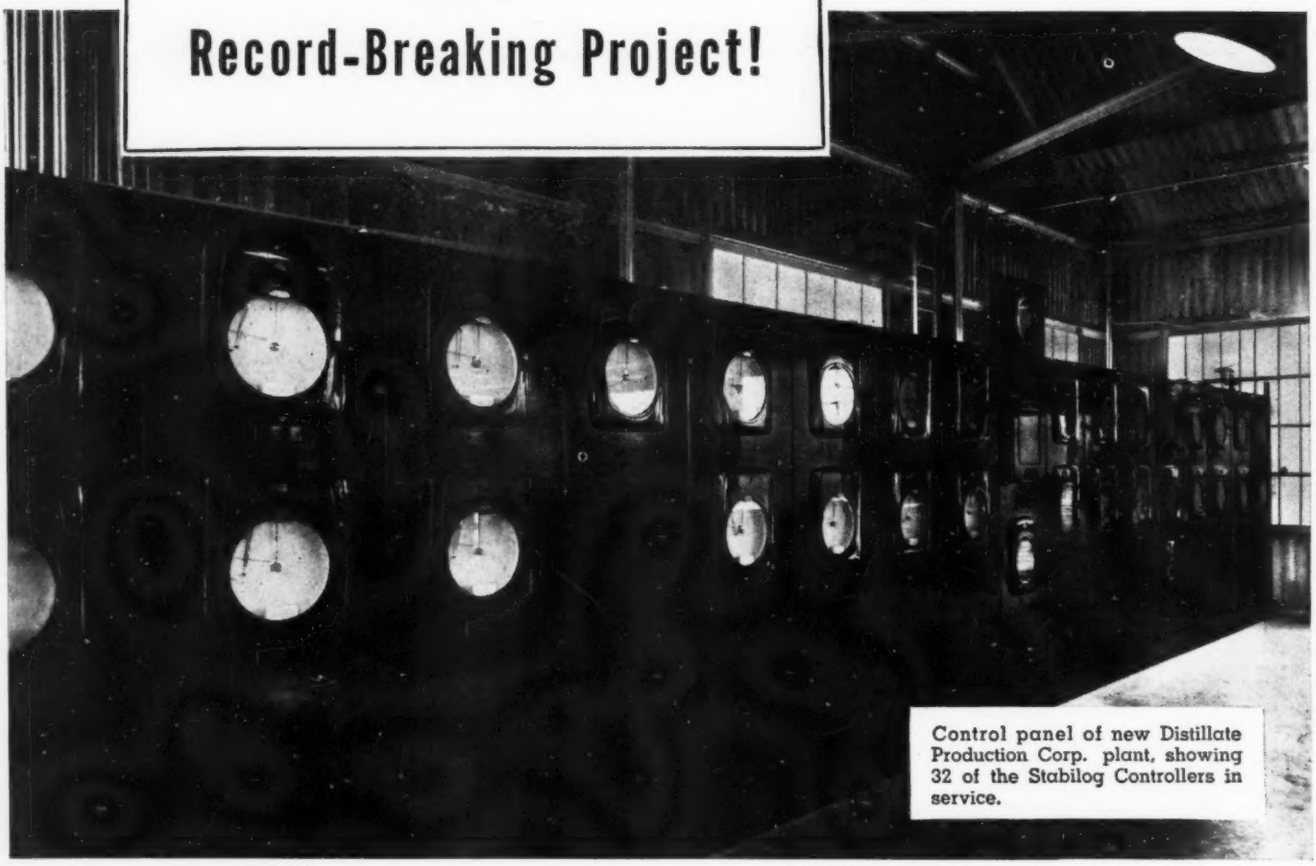
PORUS - KROME

Multiplies Engine Life

* PORUS-KROME is hard chromium, applied by the Van der Horst process that produces pores to hold oil. It reduces wear, corrosion and scuffing, and greatly multiplies engine life when used on cylinder walls, or other bearing surfaces.

VAN DER HORST CORPORATION OF AMERICA CLEVELAND 11 · OHIO
OLEAN · NEW YORK

AGAIN THE CHOICE
for a
Record-Breaking Project!



Control panel of new Distillate Production Corp. plant, showing 32 of the Stabilog Controllers in service.

Stabilog Controllers were selected by Distillate Production Corp. to help set new production "high"

THE recently-erected plant of Distillate Production Corporation in Harris County, Texas, was specifically designed to obtain very high percentages of propane and butanes. For the important job of control, the designers selected Foxboro Stabilog Controllers. Tests, to date, indicate that this plant is achieving probably the highest recovery of butanes of any similar plant in operation!

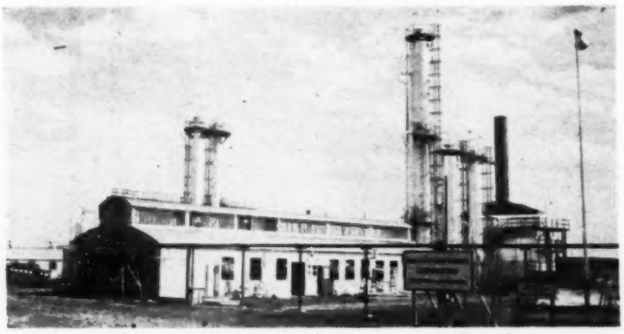
This is merely one typical example of the petroleum industry's 15-year-long preference for Foxboro Stabilog Controllers wherever smoothest, closest stabilizing control is essential. Time after time, when the newest, most-advanced processing plant of any type goes on flow, all its critical operations are under the super-control of Stabilog Controllers!

Get the facts about today's Stabilog Controller with HYPER-RESET . . . the controller that *gives process stability never even approached before!* Write for Bulletin A-330. **The Foxboro Company, 130 Neponset Avenue, Foxboro, Massachusetts, U. S. A.**

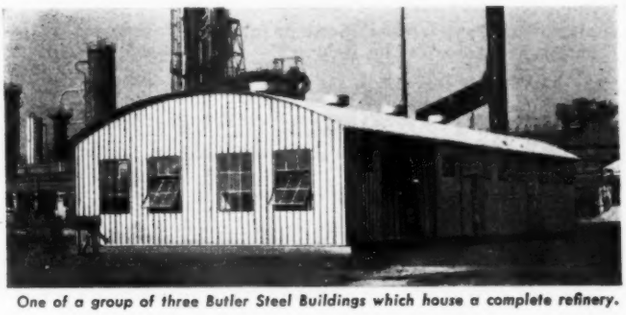
Stabilog REG. U.S. PAT. OFF. **Controllers by FOXBORO** REG. U. S. PAT. OFF.

BUTLER BUILT
STEEL BUILDINGS

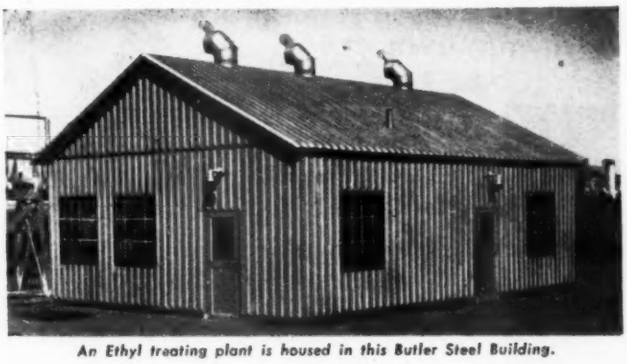
Butler Steel Building Tailor-measured to house a refinery treating plant.



Butler Steel Building Tailor-measured to house a modern refinery hot pump room, a cold pump room and control room.

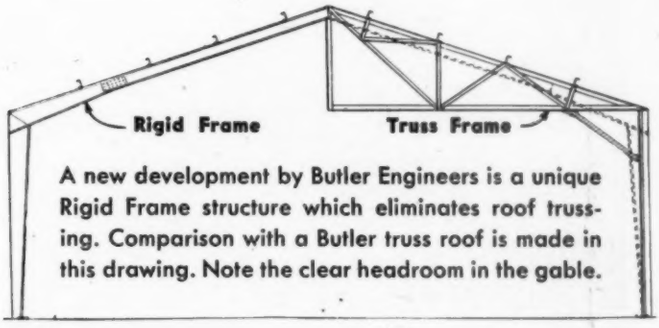


One of a group of three Butler Steel Buildings which house a complete refinery.



An Ethyl treating plant is housed in this Butler Steel Building.

War-time demands have thrown into sharp focus the advantages of three-way engineering in Butler Steel Buildings. For more than 25 years Butler Steel Buildings have been engineered—



A new development by Butler Engineers is a unique Rigid Frame structure which eliminates roof trussing. Comparison with a Butler truss roof is made in this drawing. Note the clear headroom in the gable.

1st . . . for ready adaptability to particular housing needs.

2nd . . . for speedy, economical erection.

3rd . . . for money saving mass production methods.

Many new developments are daily being proven in the strenuous tests of war. For instance, an entirely new type, hinged-arch steel building frame has been perfected. It is so simple that its parts bundle together so compactly that transport planes fly them to the battle front. Then in a matter of hours inexperienced soldiers erect a 130 ft. by 160 ft. combat hangar for fighting planes.

You will find many new advantages in postwar Butler Steel Buildings. Information on some of these can be released now for engineering study. In the meantime, it may be possible that we can fill your current requirements. Write us fully regarding them.

Awarded Our Kansas City and Galesburg Plants

This Butler Steel Building was erected after installation of heavy machinery in the pressuring house of the world's largest recycling plant. Size 40' x 214' x 15'.

BUTLER MANUFACTURING COMPANY

922 Sixth Avenue, S.E., Minneapolis 14, Minn.

SALES OFFICES: *Washington, Chicago, Atlanta, Shreveport.*

FACTORIES:
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GALESBURG
MINNEAPOLIS

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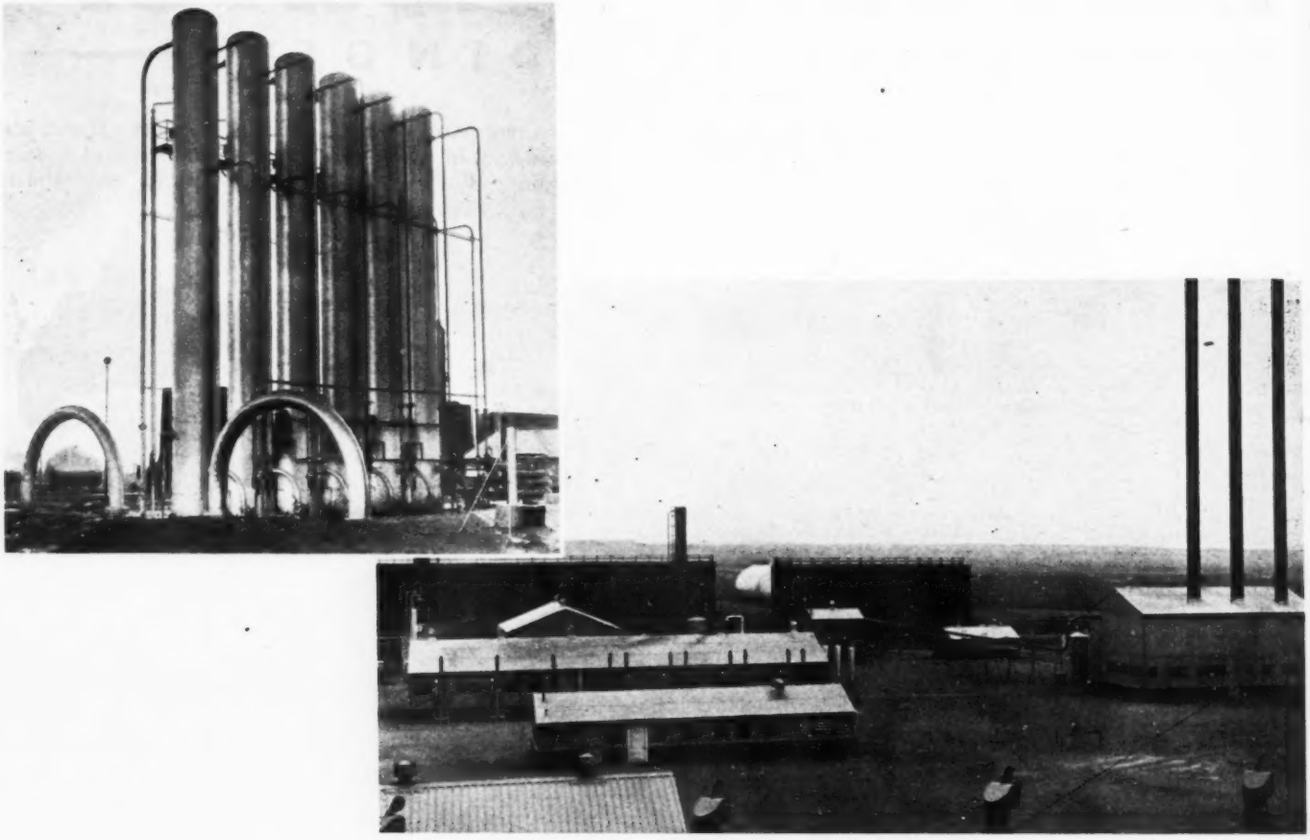
One Organization—One Responsibility



Combined Gasoline Absorption-Gas Dehydration Plant on one of the largest Gas Transmission Lines in the Industry.

We specialize in TURNKEY CONSTRUCTION of GAS PROCESSING PLANTS,

including:

Economic Analysis
Complete Design—both Process and Plant Engineering
Fabrication of Special Equipment in our own Shops
Field Construction Work with our own crews

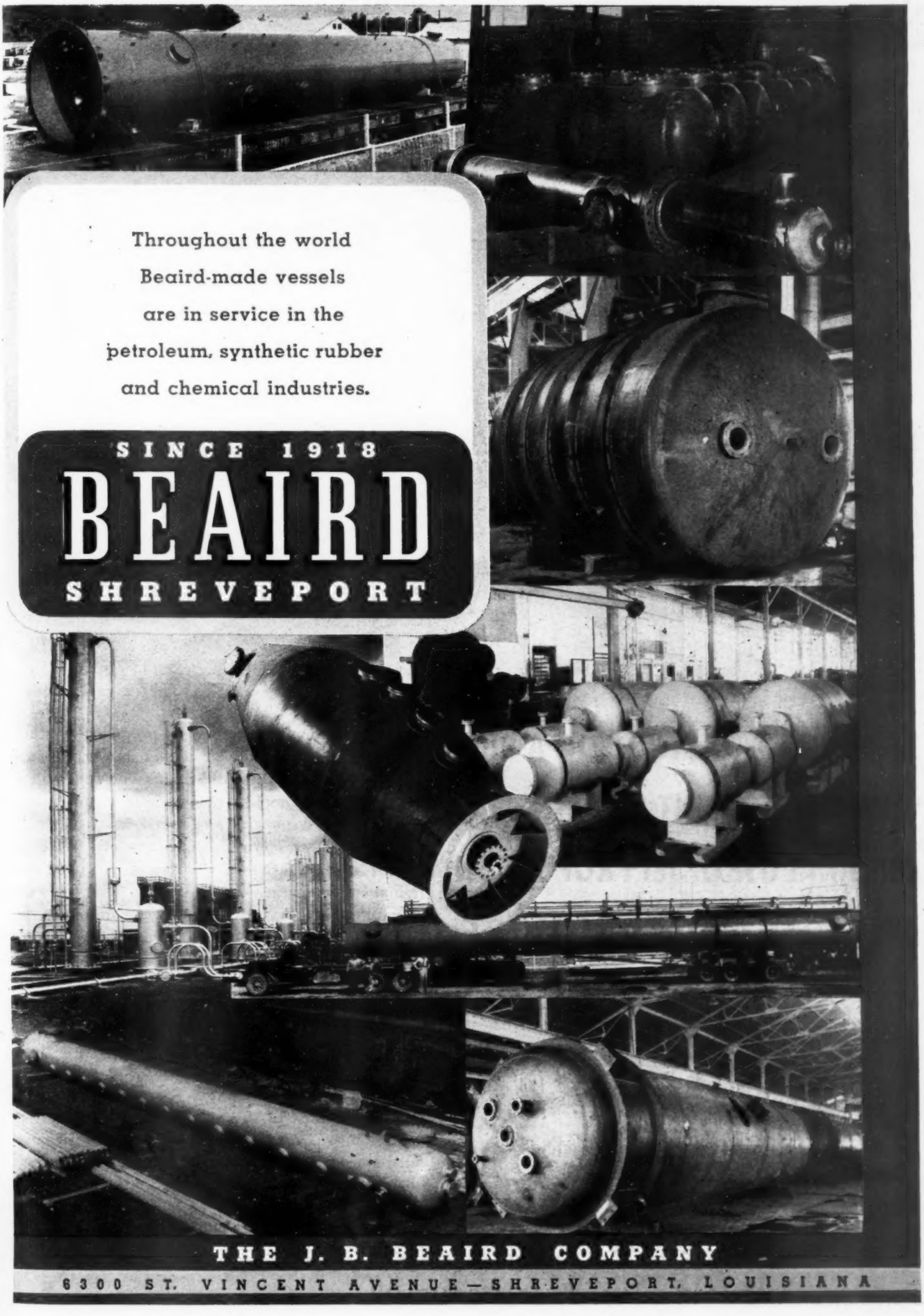
- **Distillate Recovery Plants**
- **Gas Dehydration Plants**
- **Compressor Stations**
- **Natural Gasoline Plants**
- **Stabilization Plants**

Our ability to handle all phases of projects tends to speed completion and assures efficient, economical installations.

PARKHILL-WADE
1625 SOUTH ALAMEDA STREET
LOS ANGELES CALIFORNIA

AFFILIATED WITH

THE STEARNS-ROGER MANUFACTURING CO.
1720 CALIFORNIA STREET • DENVER, COLO.


Throughout the world
Beaird-made vessels
are in service in the
petroleum, synthetic rubber
and chemical industries.
SINCE 1918
BEAIRD
SHREVEPORT
THE J. B. BEAIRD COMPANY
6300 ST. VINCENT AVENUE—SHREVEPORT, LOUISIANA

—a newspaper editorial,
January 14, 1944
MILITARY SECRET
FROM 130 B. C.
The jet propulsion plane apparently is a rocket plane without the fire and smoke. The invention, no doubt, will be credited to modern day science and ingenuity, altho the greatest wonder about jet propulsion is that mankind has let the idea kick around for so long without putting it to use.
If you want a picture of the first jet propulsion motor, flip the pages of the dictionary to the word aeolipile. The aeolipile was the first steam engine, and it was jet propulsion, pure and simple. Hero of Alexandria, a Greek mathematician and physicist, about whom little is known except that he probably lived about 130 B. C., invented or gave the first account of the aeolipile.
It is a metal basin with a cover, standing on a tripod. Hollow tubes lead up from the basin or boiler to a metal sphere, which is mounted so that it can revolve. Two jets protrude from opposite sides of this sphere, with their tips turned at a tangent to the sphere, like the arms of a swastika. Put some water in the basin, build a fire beneath it, and the steam whistles out of the jets, spinning the ball.
Men have learned to do a lot of things with steam since Hero's time, but it took them more than 2,000 years to realize that Hero had something in jet propulsion.

GLAD TO SEND YOU A RICH WOODCUT PRINT SHOWING THE ORIGINAL USE OF JET PROPULSION BY HERO OF ALEXANDRIA, 130 B.C.

The announcement of the new jet-propelled mystery war plane—unspeakably fast and powerful—just gives more proof to those old-timers who stick to the idea that there is nothing new under the sun.

A Chicago newspaper in an editorial late in January traced the idea to Hero of Alexandria and dated its first use as 130 B.C.—in what is often called the original steam engine.

READING-PRATT & CADY's research ran across the story about five years ago—and a very early drawing of the steam engine. We located an old-time woodcut craftsman and asked him to reproduce the ancient sketch.

The 5¼" x 5½" prints were so interesting and rich in their early simplicity that we offered to send a copy, mounted on mat board ready for framing, to any who would like one.

Today, because of the nation-wide interest in jet propulsion, we are repeating the offer. Please make your request on the letterhead of your company and address our offices at Reading, Pennsylvania.

READING-PRATT & CADY

MANUFACTURERS OF
READING CAST STEEL VALVES AND FITTINGS
PRATT & CADY BRASS AND IRON VALVES
D'ESTE VALVE AND ENGINEERING SPECIALTIES

Reading, Pa., Atlanta, Boston, Chicago, Denver, Houston, Los Angeles, New York, Philadelphia, Pittsburgh, San Francisco

A DIVISION OF **AMERICAN CHAIN & CABLE COMPANY, Inc.** BRIDGEPORT • CONNECTICUT

"Try 'em all..... You'll never beat LINK-BELT CHAINS"

The Ewart Detachable link, original Link-Belt Chain, was exhibited in 1876 at the Philadelphia Centennial. In the early days of oil well drilling this was the standard drive chain.

● Behind Link-Belt Oil Industry Chains is more than two-thirds of a century of research, experimentation, development, experience. Fields in every oil area of the world have proved the unfailing performance of Link-Belt Chains under every known drilling condition. There is a type for every transmission problem in the oil country and every year brings new and better advantages. Yes, Link-Belt will never stop improving chain.

LINK-BELT COMPANY

Indianapolis 6, Dallas 1, Houston 2, Los Angeles 33, Kansas City 6, Mo., New York 7, Toronto 8.
Distributors in all fields.

Also manufacturers of silent chain drives, roller chains, roller and ball bearings, and other transmission equipment, mud screens and cranes. 9450

LINK-BELT CHAINS

A TYPE FOR EVERY OIL INDUSTRY SERVICE

FACTS FOR PUMP OPERATORS

THE CANFIELD OIL COMPANY
REFINERS OF PETROLEUM

GENERAL OFFICES
CLEVELAND, O

Coraopolis, Pa.
November 1, 1943

Darling Valve & Manufacturing Company
Williamsport, Pennsylvania

Gentlemen:

You might like to know the facts regarding the Darcova Pumcups which we installed here last spring.

Previously we had been using hydraulic packing on Cameron boiler feed pumps, 10 X 7 X 13, pumping 180 gallon of water at 125°F., using 125# steam. The piston travel was 103' per minute.

Over a period of fourteen years we had changed packing about every two weeks.

On March 29, 1943, we installed your Darcova Pumcups with Darling pistons. These cups are still in service and are now beginning their eighth month.

We have not only gotten our money's worth out of the cups but have saved money and time. We have now installed Darcova Pumcups on two other pumps, one pumping oil and one pumping water.

Very sincerely,

THE CANFIELD OIL COMPANY

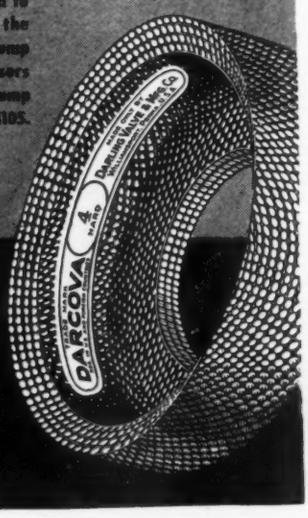
By R. W. Hela
R. W. Hela,
Superintendent

RWH:MLB

Darcova Pumcups have been used by leading operators for more than thirty-five years. Darcova Pumcups can readily be applied to any reciprocating pump. ● By employing the simple cup principle, Darcova increases pump capacity and pumping efficiency. ● Users experience savings up to $100 per pump per year. Send for free bulletin No. 4105.

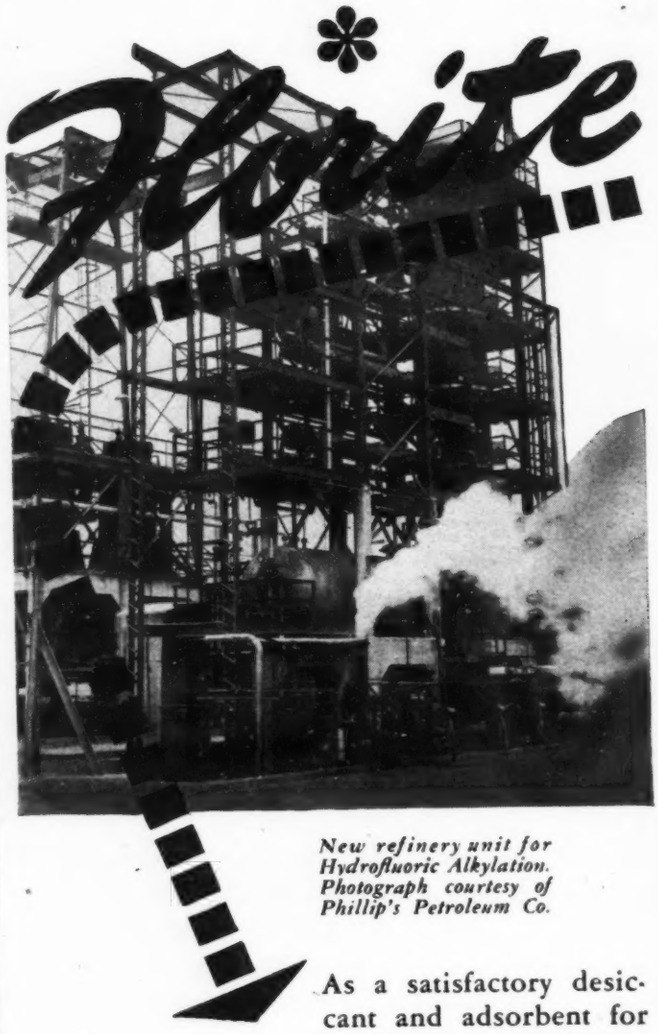
DARCOVA

THE ORIGINAL COMPOSITION CUP



DARLING VALVE & MANUFACTURING COMPANY
WILLIAMSPORT, PA.

Hydrofluoric Alkylation makes important use of



New refinery unit for Hydrofluoric Alkylation. Photograph courtesy of Phillip's Petroleum Co.

As a satisfactory desiccant and adsorbent for exacting technical processes like hydrofluoric alkylation, FLORITE is approved by leading industrial concerns. The modern plant here illustrated is typical of the extent, complexity, and very highly specialized character of installations devoted to such refining processes.

FLORITE is remarkable for its long-term effectiveness, which favors economical operation in the drying of propane, butane, air, nitrogen, carbon dioxide, refrigeration compounds, and other fluids. Write for data. Specific inquiries are welcomed by the manufacturers.

★Trademark Registered

FLORIDIN COMPANY, INC.
ADSORBENTS

Room 54, 220 Liberty Street — Warren, Pa.

Which catalytic process is backed by quick and accurate

LABORATORY EVALUATION?

Houdry maintains for the service of its licensees probably the best-equipped and most capably staffed laboratory in the world, devoted entirely to catalytic research. It is based on the most extensive and the most successful commercial experience of any catalytic cracking process.

To this laboratory Houdry licensees may bring for prompt, accurate solution any problem relating to the production of aviation or automobile gasoline. To it, the licensee may submit samples of his stock and, within ten days to two weeks, get the answer. Leaving nothing to chance, nothing to guesswork, Houdry Laboratory Evaluation tells him exactly what is the best way to process that particular crude.

This highly developed technique of laboratory evaluation saves Houdry licensees much time and money. It enables them to crack their stocks at optimum conditions, thus assuring highest possible yield.

Houdry Catalytic Processes and the T. C. C. Process are available to all American refiners, under license arrangements, subject to approval by the United States Government.

Houdry PROCESS CORPORATION
WILMINGTON, DELAWARE

LICENSING AGENTS: H. B. BADGER & SONS CO., Boston, Massachusetts • BECHTEL-McCONE-PARSONS CORP., Los Angeles, California • THE LUMMUS COMPANY, New York City, New York

HOUDRY CATALYTIC PROCESSES ... FOR VICTORY IN WAR AND PROGRESS IN PEACE

DOUBLE SEAL PISTON RINGS for PIPE LINE PUMPING ENGINES

- ✓ *Help engines deliver more power with higher compression*
- ✓ *Create very satisfactory savings in fuel and lubricating oil*
- ✓ *Reduce carbon formation, ring sticking and breakage*
- ✓ *Save many engine overhauls and*
- ✓ *Lengthen life of engine*
- ✓ *Available for shipment* NOW!

Rings from our stocks of more than 500,000 in all sizes required for oil field and pipe line engines are usually shipped the same day the order is received. Any reasonable number of made-to-order rings can be produced and shipped within three to ten days from receipt of order.

WRITE TODAY for information on how Double Seal Piston Rings can drastically reduce engine operating and maintenance cost.

DOUBLE SEAL RING CO.
GENERAL OFFICES—FORT WORTH, TEXAS
FACTORIES
2065 Montgomery St., Fort Worth, Texas - 157 Chambers St., New York, N. Y.
6201 Wilmington Ave., Los Angeles, California

USE THE COUPON

DOUBLE SEAL RING CO., Box 566-E, Fort Worth 1, Texas

☐ Please send without cost or obligation, information on how Double Seal Rings can save money on the operation of diesel and gas engines.

☐ The Double Seal Piston Ring Handbook for Engineers.

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City_____ State_____

National Sections

NATIONAL CONDENSING and COOLING SECTIONS were not "brought off the shelf" by the War Emergency.

Each year since 1930 an increasing number of NATIONAL SECTIONS have been shipped to petroleum refineries and chemical plants.

NATIONAL SECTIONS are the *ONLY* Cast Iron Condensing Surface whose use has increased during the past ten years.

NATIONAL SECTIONS will still be available when the war is over. Consider this factor when specifying equipment for current requirements.

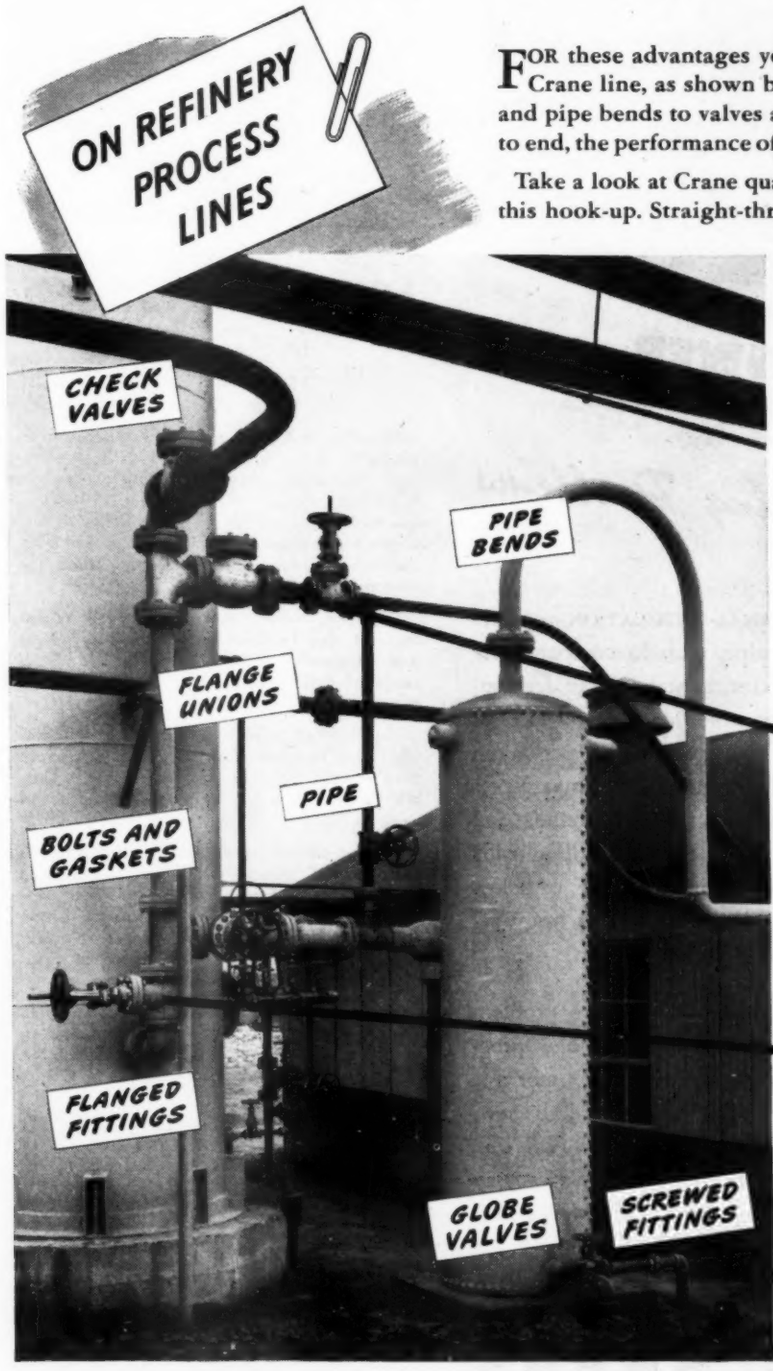
For further information—write on your letterhead.

INDUSTRIAL DIVISION

THE NATIONAL RADIATOR COMPANY
237-L Central Avenue · Johnstown, Pa.

From beginning to end, you can get it from Crane

One high standard of quality throughout... One source of supply... One responsibility for all materials



FOR these advantages you can thank the unusual completeness of the Crane line, as shown by the installation at left. Every part, from pipe and pipe bends to valves and fittings, comes from Crane. And from end to end, the performance of every part is assured by Crane superior quality.

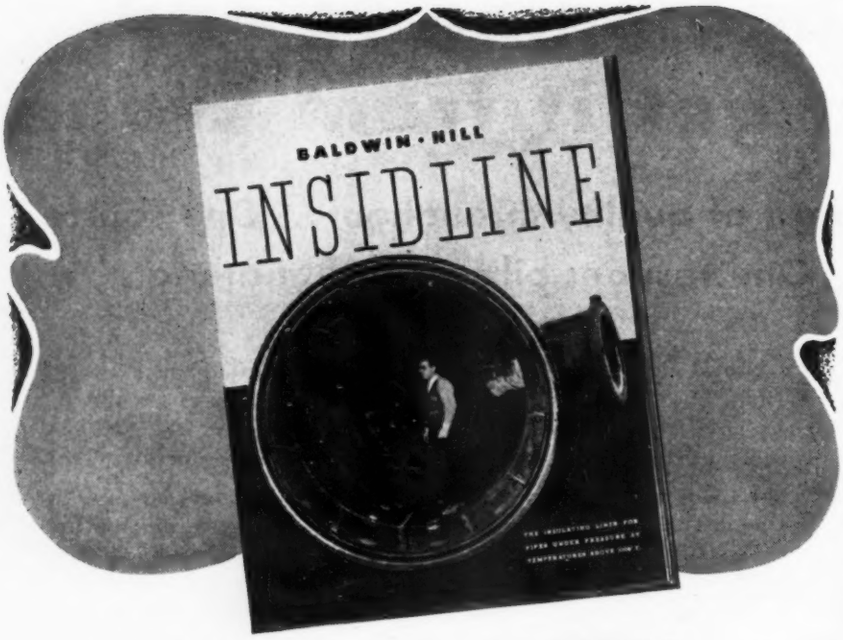
Take a look at Crane quality through the cast steel wedge gate valves in this hook-up. Straight-through ports minimize turbulence, erosion, and resistance to flow. Strong tee-head disc-stem connection, easily lubricated ball-bearing yoke, and ample non-corrosive stem bearings assure smooth operation. Disc is fully guided and accurately seated by extra long guide ribs.

With such refinements marking every item in the world's largest line of piping equipment, Crane is your magic word for better fluid handling service, whether you need a single fitting or an entire system. Crane Co.'s 89-year leadership in its field sees to that.

CRANE CO., General Offices: 836 South Michigan Avenue, Chicago 5, Illinois.

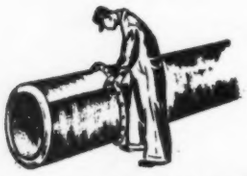
CRANE

VALVES · FITTINGS · PIPE · PLUMBING · HEATING · PUMPS



THE LOGICAL ANSWER

to High-Temperature, Pressure-Piping Problems



Insidline installations in pipe from 2" I.D. to 36" I.D. are made with a cartridge type of insulation that is built up first, and then drawn into the pipe.

In larger diameters from 36" up to over 100", a panel type of Insidline is built up on the inside of the pipe.

INSIDLINE, AN INTERNAL INSULATION, enables ordinary carbon-steel pipe, with its comparatively light weight and low cost, to stand up under conditions never before possible. Many new processes involve the piping of flue gases, steam, petroleum gases, hydrogen, and fluid catalysts at temperatures up to 1500° F., pressures up to 300 pounds, and velocities up to 500 feet per second. Insidline holds the temperature of the piping to 650° F. or below where it can be operated indefinitely at the usual stress allowances.

If you have a high-temperature piping problem today . . . or if you are contemplating new processes involving high temperatures for tomorrow, it will pay you to send for a copy of this new, free INSIDLINE booklet now. *Baldwin-Hill Co., 563 Klagg Ave., Trenton 2, New Jersey. Plants in Trenton, N. J.; Kalamazoo, Mich.; Huntington, Ind.*

Baldwin-Hill

COMPANY

BH

HEAT & COLD INSULATIONS

YOUR WATER SYSTEM

Might Be Called for Extra Duty Tonight

FIRE—that killer of man and destroyer of property strikes suddenly and without warning! Standing guard, after performing its daily duty, is your water system. If it bears the name of LAYNE, be assured that it has a great stand-by reserve of power and productivity ready to be unleashed when the emergency call comes.

In many, many cases Layne Well Water Systems, due to their extra reserve of power and productivity, have saved untold thousands of dollars worth of property in cases of sudden emergency.

Layne Well Water Systems are specifically built to give their owners much more than normal daily operational service. They are built to give protection to property and lives.

If your city or manufacturing plant needs more water, please remember that Layne Well Water Systems produce great quantities at exceptionally low cost and at the same time provide an extra reserve of power and productivity that stand guard in cases of emergency.

For fully illustrated literature on Layne Well Water Systems, address Layne & Bowler, Inc., General Offices, Memphis 8, Tenn.

AFFILIATED COMPANIES: Layne-Arkansas Co., Stuttgart, Ark. ★ Layne-Atlantic Co., Norfolk, Va. ★ Layne-Central Co., Memphis, Tenn. ★ Layne-Northern Co., Mishawaka, Ind. ★ Layne-Louisiana Co., Lake Charles, La. ★ Louisiana Well Co., Monroe, La. ★ Layne-New York Co., New York City ★ Layne-Northwest Co., Milwaukee, Wis. ★ Layne-Ohio Co., Columbus, Ohio ★ Layne-Texas Co., Houston, Texas ★ Layne-Western Co., Kansas City, Mo. ★ Layne-Western Co. of Minnesota, Minneapolis, Minn. ★ International Water Supply Ltd., London, Ontario, Canada

LAYNE

WELL WATER SYSTEMS

DEEP WELL PUMPS

BUILDERS OF WELL WATER SYSTEMS FOR INDUSTRIES AND MUNICIPALITIES

Will it just "do," or... will it "DO THE JOB"

Fig. 559—Iron Body Bronze Mounted Swing Check Valve for 125 pounds W. S. P. at 450 F. Has flanged ends, bolted flanged cap and regrindable, renewable bronze seat and disc. Sizes 2" to 12", inclusive. Also available for 250 pounds W. S. P. in sizes from 2" to 10", inclusive.

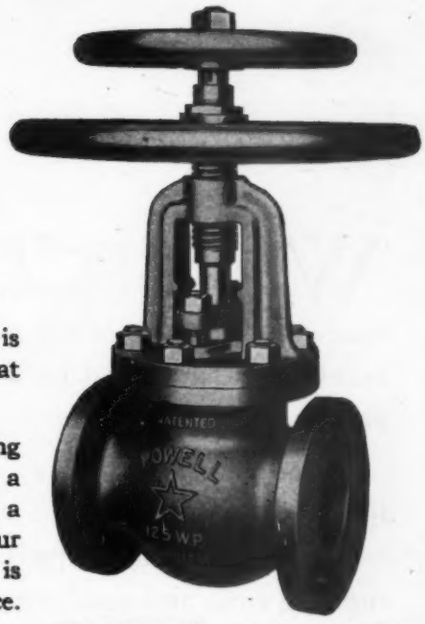


Fig. 2457 S. W.—125-Pound Stainless Steel Globe Valve equipped with the Powell Patented Seat Wiper. This ingenious internal regrinding device—patented in 1935—is another example of how Powell Engineering helps to solve difficult and unusual flow control problems. It assures tight closure of valves handling heavy viscous or gelatinous media or suspensions in solution that precipitate over seat and disc faces. The disc is lowered to the seat by operating the large handwheel. The auxiliary (small) handwheel is then operated back and forth to regrind or lap the seat and disc faces together, thereby clearing both seat and disc faces of any adhering material and insuring a metal to metal contact. Powell Globe, Angle and "Y" Valves can be equipped with the Patented Seat Wiper.

Fig. 1793—Iron Body Bronze Mounted Gate Valve for 125 pounds W. S. P. at 450 F (12" and smaller), 100 pounds W.S.P. (14" and larger). Has flanged ends, outside screw rising stem, bolted flanged yoke, bronze seat and taper wedge solid disc. Sizes 2" to 30", inclusive.

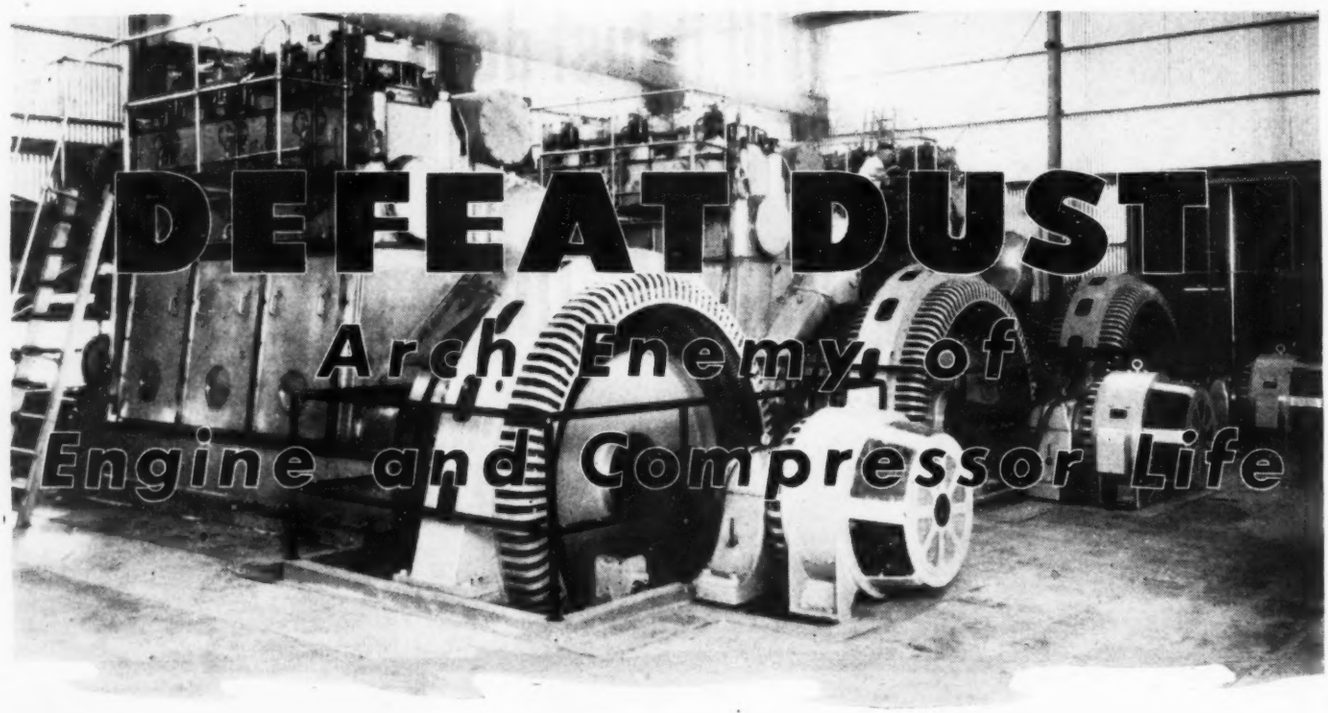
"There is a valve that will "*do*"—or "there is a POWELL Valve that will *do the job*"—what a vital difference in meaning.

But as long as you have POWELL Engineering at your service, you'll never have to make a valve "do"—because POWELL not only has a complete line of standard valves as listed in our general catalog but—POWELL Engineering is ready at all times to offer *specialized* service.

Shown here are three of POWELL's complete line of Valves. These valves are correctly engineered in every detail for controlling the flow of low-pressure steam, oil, water or gas.

The Wm. Powell Co.
Dependable Valves Since 1846
Cincinnati 22, Ohio

POWELL VALVES

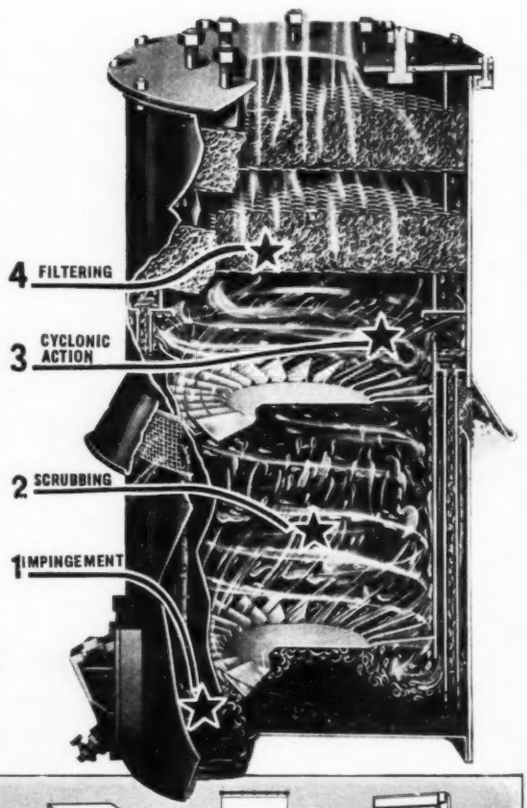


WHEN you protect power equipment with AAF air cleaners you prevent the unnecessary costly, time-consuming breakdowns which always result from excessive wear caused by abrasive dust and grit that attacks the vitals of your engines and compressors.

Throughout the nation, Cycoil cleaners are prolonging the useful life of valuable power equipment —permitting uninterrupted operation on stepped-up running time and accelerated production schedules.

The cost of Cycoil's "preventive maintenance" is insignificant compared to savings in wear, running time and man-hours. Send for facts on the Cycoil and other AAF engine and compressor filters for every air and gas cleaning requirement.

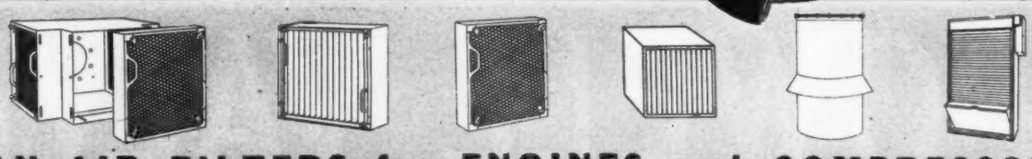
THE CYCOIL OIL BATH AIR CLEANER



AMERICAN AIR FILTER CO. INC.
384 Central Ave., Louisville, Kentucky
In Canada: Darling Bros., Ltd., Montreal, P. Q.

AAF

The fundamental advantage of the Cycoil Oil Bath cleaner is that the incoming air stream picks up an unusually large quantity of oil which is thoroughly mixed with the air (causing a scrubbing or precleaning action), and then thrown out by centrifugal action before the air stream enters the filter cell. This results in reducing the dust load on the filter cell and insuring continued self-cleaning action.



AMERICAN AIR FILTERS for ENGINES and COMPRESSORS

GET THE CHAIN THAT'S BACKED UP WITH

MORE SERVICE

Today, when you buy Whitney Chains, you're not only getting a more serviceable rugged chain, built of alloy-armored steels to stand the toughest non-stop operation, take shocks and overloads, and *keep delivering* full power to the job . . . but you're also getting the oil fields' top-notch distributor on-the-spot service. A skilled service ready to supply you with the equipment or engineering assistance you need, *when you need it.*

Specify

WHITNEY CHAINS

Distributed by

THE CONTINENTAL SUPPLY CO., Dallas, Texas

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Los Angeles, Cal.

The Whitney Chain & Mfg. Co., Hartford, Conn.

SIMPLICITY OF DESIGN MEANS EASIER MAINTENANCE

GOOD VALVE CARE is just good business

NOW, especially, when the demand for valves is taxing deliveries, it is imperative that you make your present valves last longer and serve better.

It's a challenge to every maintenance man to keep an eagle eye on the valves he now has in service . . . to see that they are checked and serviced regularly and thus forestall, as far as possible, the need for new valves.

Lunkenheimer Valves are easy to keep in good condition. Simplicity of design, with a minimum of working parts, makes them readily accessible for inspection and maintenance follow-up.

Let your Lunkenheimer distributor help you with your maintenance, repair and operating problems. His facilities and experience are at your call.

ESTABLISHED 1862
THE LUNKENHEIMER CO.
"QUALITY"
CINCINNATI 14, OHIO, U. S. A.
NEW YORK 13 CHICAGO 6
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EXPORT DEPT. 318-322 HUDSON ST., NEW YORK 13, N. Y.

Bronze Double Disc Gate Rising Stem

It fits perfectly . . . .

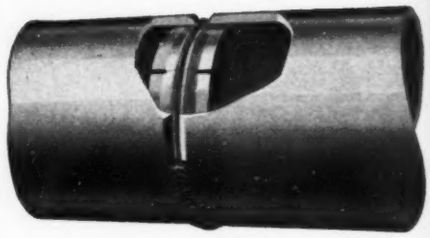
One body takes either the rising stem or non-rising stem trim assembly. A timely feature when it's necessary to convert from one type to the other. Simply loosen the trim assembly and lift out. The body remains in the line.

Bronze Wedge Disc Gate Non-rising Stem

LUNKENHEIMER VALVES

for STRONG REINFORCED WELDED JOINTS

Use WEDGE *Split* CHILL RINGS



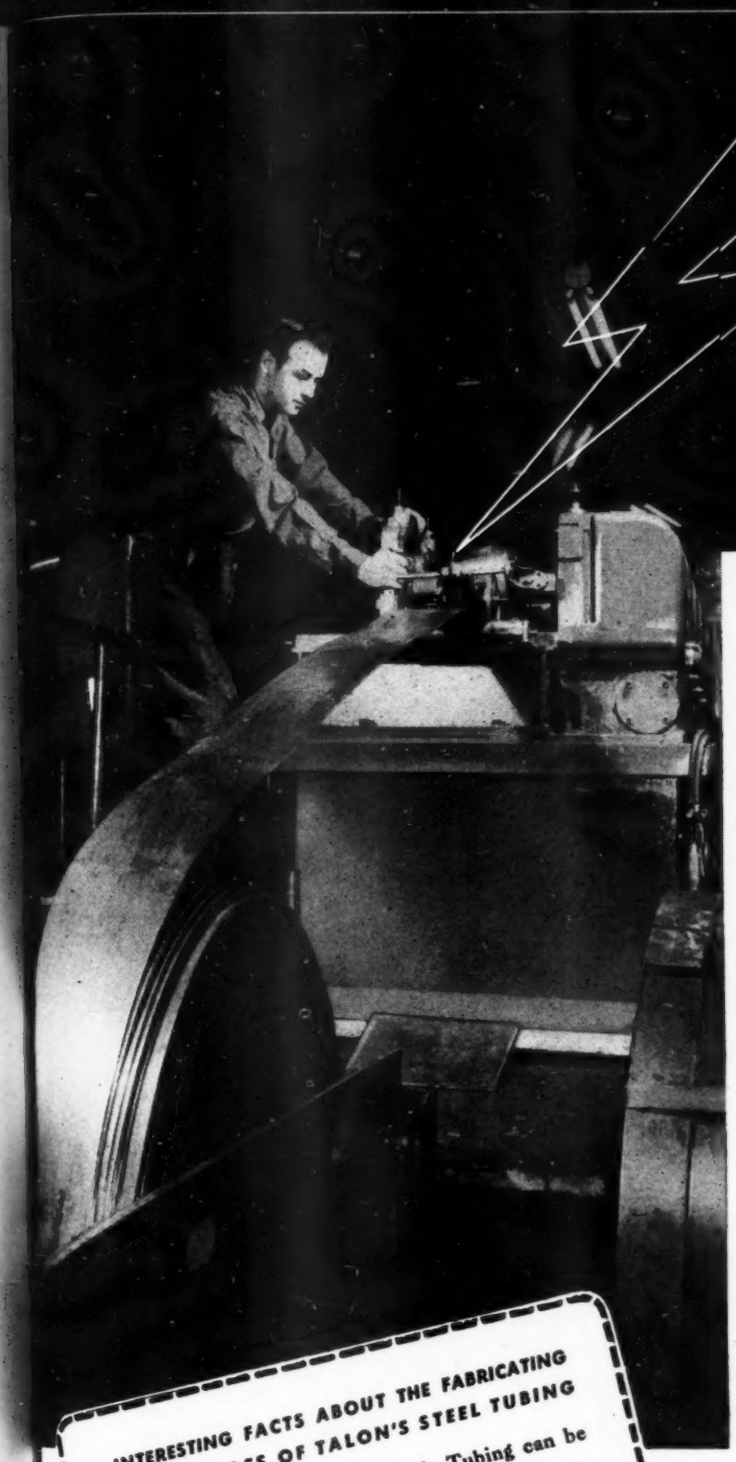
A PIPE LINE IS NO STRONGER THAN ITS WEAKEST PART. At one time the joints were the WEAK points but that is reversed now. WEDGE Chill Rings with the Patented SPLIT Feature REINFORCES the joints. Under shock, strain or vibration the pipe will fail before the reinforced joints. In addition to giving you stronger joints they will prevent serious and costly breaks. WEDGE Chill Rings offer many other advantages. They assure 100% penetration, this prevents breaks. You can weld pipe FASTER and BETTER even with less skilled help. WEDGE Chill Rings enable you to align pipe faster which saves labor and they also reduce the amount of weld material required. Why not investigate?

Write for Information

WEDGE PROTECTORS, INC.

9522 Richmond Avenue Cleveland 5, Ohio

WEDGE *Split* CHILL RINGS SAVE MONEY

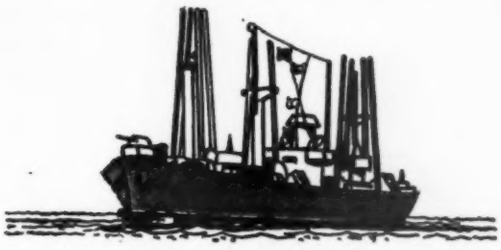


● In the manufacture of Talon's Electric Welded Steel Tubing, coiled, flat stock feeds continuously through forming rolls which shape the strip into a round. Then the butted edges pass under the electric resistance welding unit to form a continuous tube wall.

Careful selection of strip assures correct wall thickness, concentricity, and accurate size in the finished tubing. Talon checks each coil for accuracy of gauge and width and condition of surface. The analysis, hardness, and microstructure of the steel are also checked at regular intervals. That is why Talon's Tubing will meet the requirements of your particular application. Your inquiries will receive immediate and careful attention.

INTERESTING FACTS ABOUT THE FABRICATING ADVANTAGES OF TALON'S STEEL TUBING

Change of Section . . . Talon's Tubing can be beaded, expanded, swaged, spun, flanged, upset, grooved, rolled, fluted, flattened, tapered, and otherwise changed in cross-section to meet an endless variety of design requirements.



Talon's Tubing is equal to the tough jobs for which it is used. It is dependable in our ocean-going vessels where long tie-ups for tube replacements must be avoided as much as possible. And remember, Talon's rigid inspection assures this long tube life and less maintenance.

PRESSURE **MECHANICAL**

TALON . . INC.

STEEL TUBE DIVISION OIL CITY, PENNA.

ROLL OUT THE BARRELS—

Somewhere in the South Pacific, these hundreds of drums of oil are being rolled ashore from a landing lighter, where they await removal by work gangs of U. S. Marines.

In all parts of the globe this same scene is being repeated day after day. To keep pace with this tremendous demand the oil industry must keep rolling out these drums of war in endless array.

A large measure of that responsibility falls on the many manufacturers who supply the necessary tools and equipment. Jas. P. Marsh Corporation is among these. The contribution of Marsh Gauges to the overall results may be small, but for the vital posts they do fill Marsh's 75 years of gauge-making experience has well prepared them.

JAS. P. MARSH CORPORATION, 2097 Southport Ave., Chicago 14, Illinois

THE GAUGE WITH THE "RECALIBRATOR"

Illustrated here is the Marsh Mastergauge, a gauge that brings new meaning to accuracy and stamina with its precision-built movement and bourdon tube bored from solid bar stock. That "Recalibrator" makes it the ideal gauge for today's needs, because it means that accuracy is lacked in for keeps. If ever the gauge is knocked out of adjustment, a twist of the "Recalibrator" screw makes it accurate again at all points on the dial—something that has never been satisfactorily accomplished before.

MARSH GAUGES

TOPSALL

NEW BEDFORD CORDAGE

New Bedford Cordage has developed TOPSALL (treated sisal) for Catlines, Drilling Cables, Torpedo Lines, Spinning Lines, and Bull Ropes to fill the vacancy created by Uncle Sam's all out need for manila.

TOPSALL is just what the name implies, it tops all. Made from the best available sisal fibers, oiled and treated . . . TOPSALL has the same high quality construction and uniformity that has made New BEDFORD Rope famous . . . TOPSALL is available in the same sizes as "New Bedford" Manila and "Maritime" Manila with maximum breaking strength of 80% of "New Bedford" Manila. Because of the difference in tensile, due allowance in size should be made, when ordering.

For rope that will give uniformly good service, flexible and easy-to-handle, ask your Continental Representative for New Bedford TOPSALL.

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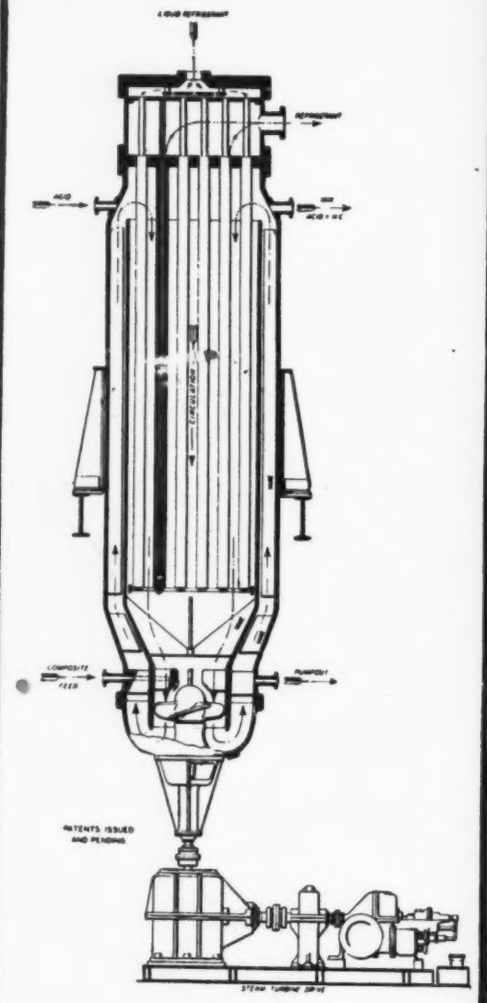
CONTINENTAL

SERVING THE OIL AND GAS INDUSTRIES

STRATCO ALKYLATE



STRATCO ALKYLATION CONTACTOR

Higher Yield
Higher Octane

Result:

MORE FIGHTING FUEL

STRATFORD ENGINEERING
CORPORATION
PETROLEUM REFINING ENGINEERS
DIERKS BLDG. KANSAS CITY, MO.

The Popular Choice

FOR WELLS ON THE BEAM—

THE G-E TRI-CLAD SPLASHPROOF MOTOR,

with its three protection features

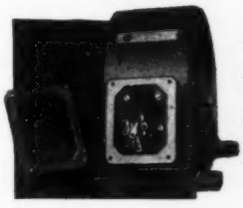
THIS motor will give you long and dependable service under your tough operating conditions. Its clean-cut design and convenience features make it easy to install and maintain.

Or, for those conditions where a completely enclosed motor is required, the G-E totally enclosed fan-cooled motor will provide faithful, uninterrupted operation in all kinds of weather, with little care.

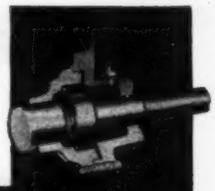
To help you plan your maintenance program, our handy booklet on the care of G-E Tri-Clad splashproof motors gives part-by-part inspection and cleaning procedure. Call or write our office for Bulletin GEJ-910, "Servicing Splashproof Motors Installed Out-of-doors." For general information on the splashproof motor, ask for Bulletin GEA-3595. *General Electric Company, Schenectady, N. Y.*

Protected

—from physical damage by one-piece, cast-iron frame and end shields, well-baffled ventilating openings, and waterproof conduit box.



—from electrical breakdown by coil windings of Formex* wire and an external coat of Glyptal No. 1201-B Red for high dielectric strength.



—from operating wear and tear by completely enclosed ball bearings of high load-carrying capacity, effectively sealed to keep out liquids.

**Reg. U.S. Pat. Off.*

Every week 192,000 G-E employees purchase more than a million dollars' worth of War Bonds.

GENERAL ELECTRIC

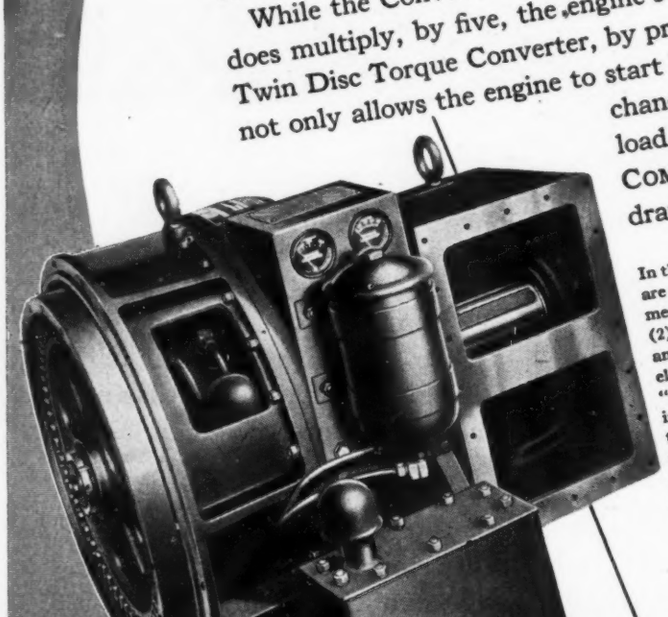
750-211-8080

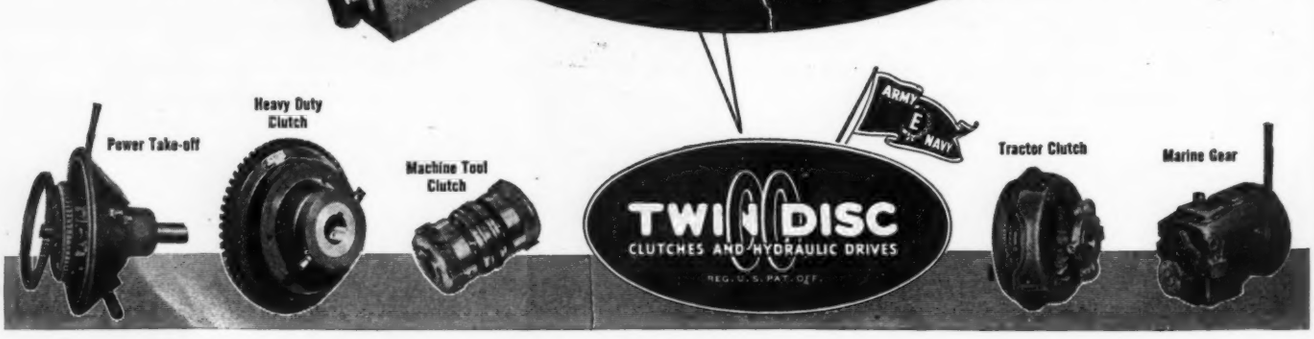
GIVES A PIGMY THE STRONG BACK OF A GIANT . . . .

With the addition of a Twin Disc Hydraulic Torque Converter*, internal combustion engines, which otherwise would be too small for the job, become efficient and practical power units because the Converter gives the engine the added torque it needs AT ITS MOST VULNERABLE POINT: *when starting heavy loads*. That's why we say the Twin Disc Hydraulic Torque Converter* gives a pigmy the strong back of a giant. While the Converter does not increase the engine's horsepower, it does multiply, by five, the engine's torque at stalling . . . thus, the Twin Disc Torque Converter, by providing the extra torque needed, not only allows the engine to start heavier loads, but eliminates any chance of stalling the engine when the load is applied. TWIN DISC CLUTCH COMPANY, Racine, Wisconsin, (Hydraulic Division, Rockford, Illinois).

In the new series of Twin Disc Hydraulic Torque Converters are three important refinements: (1) a new sealing arrangement which is far more stable than the one previously used; (2) bearings have been removed from the Converter fluid and are independently lubricated; (3) an external pump eliminates the need for an aspirator or injector to prevent "cavitation" (the forming of vacuum pockets or "cavities" in the fluid). These improvements have not only added to the performance of the Converter but have sharply reduced maintenance. You'll want to know the whole story of this new model. That's why we've told it in an interesting bulletin just off the press. We invite you to ask your dealer or write direct for Bulletin No. 135.

*Lysholm-Smith type.





BAROID LABORATORY TECHNICIANS AND FIELD ENGINEERS HELP MAKE HOLE "ahead of the bit."

A Baroid Sales Division research conference where Laboratory and Field Engineers meet to discuss problems of drilling mud control. Due to such conferences, many drilling problems are solved before being encountered by the operator. This is an example of making hole "ahead of the bit."

Improved materials and equipment contribute largely to the ability of modern operators to make hole speedily, safely and at less expense in formations which were almost impossible to penetrate a few years ago. But to a large extent ever-increasing knowledge about drilling muds and their control has been responsible for the great improvements in drilling technology.

Baroid Sales Division takes pride in the fact that Baroid Laboratory Technicians and Service Engineers, in cooperation with oil company mud engineers, have contributed substantially toward making this progress possible.

From grass-roots to completion, use Baroid Products and Service. They have helped to make hole "ahead of the bit" in thousands of wells.

Patent Licenses, unrestricted as to sources of supply of materials, but on royalty bases, will be granted to responsible oil companies and operators to practice the inventions of any and/or all of United States Patents Nos. 1,807,082; 1,991,637; 2,041,086; 2,044,758; 2,064,936; 2,094,316; 2,119,829; 2,214,366; 2,294,877; 2,304,256 and further improvements thereof. Applications for Licenses should be made to Los Angeles office.

BAROID SALES DIVISION

NATIONAL LEAD COMPANY Baroid Sales Offices: Los Angeles 12 • Tulsa 3 • Houston 2

Baroid Products: Baroid and Colox • Aquagel • Fibrotex • Baroco • Stabilite • Aquagel-Cement • Smentox Impermex • Zeogel • Micatex • Anhydrox • Testing Equipment • Baroid Well Logging Service

Continental Red Seal Engines

Your Dollars Are Power, too . . . Buy War Bonds

POWER TO WIN

This new Continental Red Seal Engine is built to "take it."

It is the model R602 which means a six-cylinder engine with a piston displacement of 602 cubic inches.

Gruelling work and uninterrupted service have endeared this engine to thousands of our fighting men overseas.

It is particularly adapted to Oil Field Service.

ARMY E NAVY

Awarded to the Detroit and Muskegon Plants of Continental Motors Corporation for High Achievement

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DALLAS — National Welding & Grinding Co.
HOUSTON — C. Jim Stewart & Stevenson Co.
LONGVIEW — Standard Tool & Machine Co.
OKLAHOMA CITY — Diesel Power & Mach. Co.
TULSA — Diesel Power & Machinery Co.
WICHITA FALLS — Wichtex Machinery Co.

Continental Motors Corporation
MUSKEGON, MICHIGAN

One or more Petreco-licensed processes is in daily use in virtually every oil producing and refining district. Since it is an accepted fact that all operating methods are not universally practicable, this wide application of the Petreco Processes is indicative of their basic soundness.

Petreco's use by a widely representative cross section of the petroleum industry's leaders, both large and small, is a further evidence of results attained, services rendered. If you have a de-emulsification or salt extraction problem in connection with your crude oil, get in touch with a Petreco engineer. Because Petreco operations are national in scope, Petreco engineers are easily available, everywhere.

COMPLETE OIL STATE COVERAGE

WITH PETRECO PROCESSES

PETROLEUM RECTIFYING COMPANY

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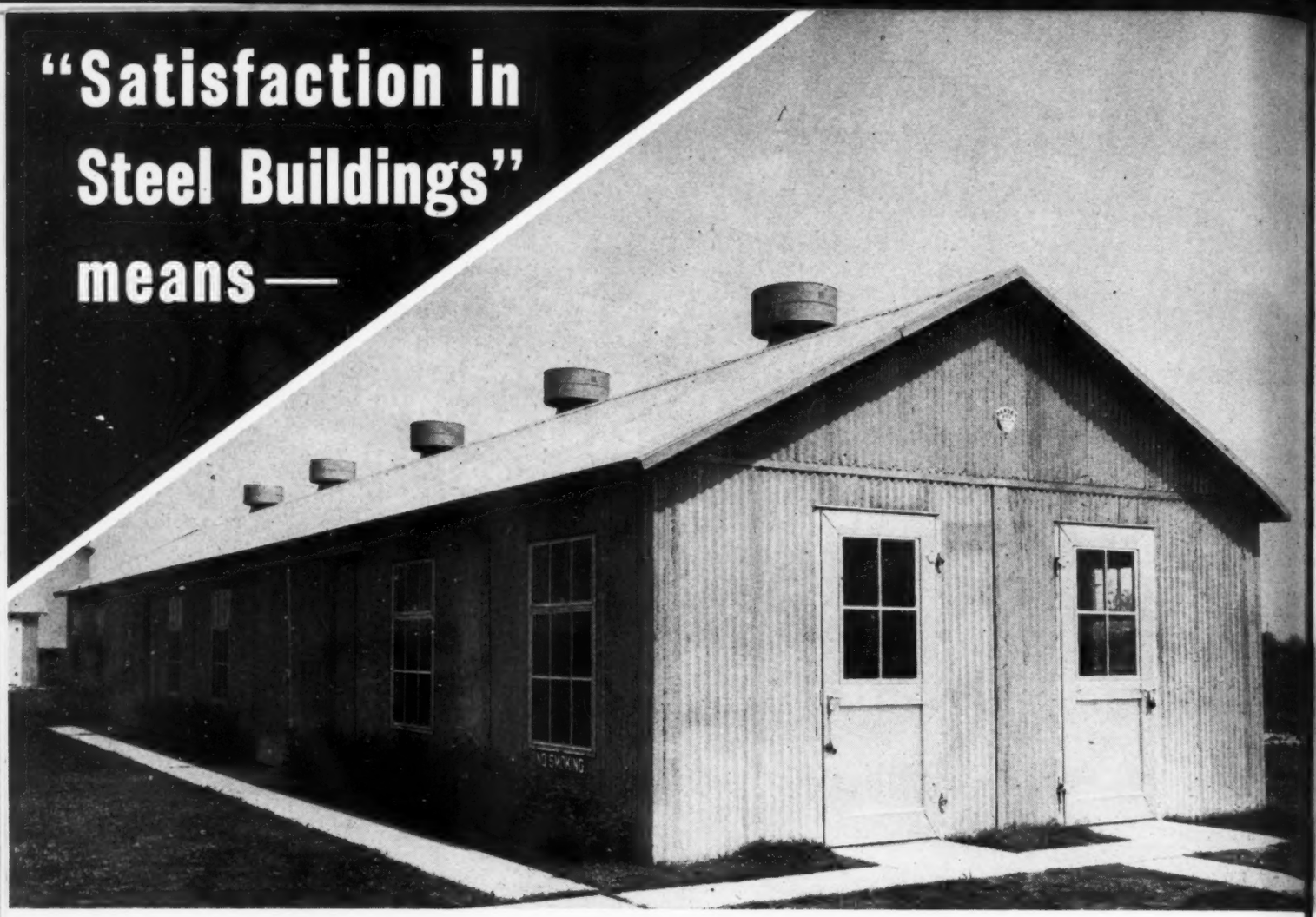
Representatives in principal production and refining centers

DESALTING **DEHYDRATING**

"Satisfaction in Steel Buildings" means—



Braden Sectional Steel Buildings

That Braden Buildings represent the large percentage of industrial steel buildings now in use in the South and Mid-Western parts of the country is due to:

Individual designs assembled from standardized factory fabricated panels; *Portability*, resulting in practically 100% salvage; *Economy* in first cost, maintenance and re-assembly; *Ruggedness*, resulting in strength and long life; *Fire* resisting and lightning proof. Braden Steel Buildings completely meet the requirements for pipe line stations. They are weather tight and as permanent as the equipment they protect—at the same time being subject to easy change in size or to complete re-erection. *Braden engineers can assist you with layout and building plans.*

BRADEN STEEL CORPORATION, 107 East Admiral Blvd., Tulsa 3, Oklahoma

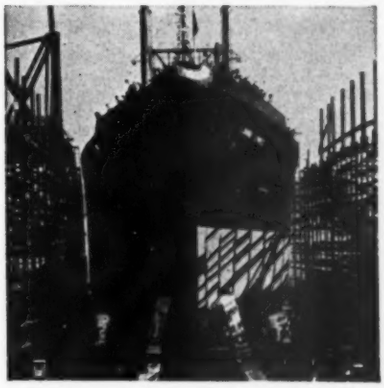
Subsidiary of MOORLANE COMPANY

Gulf Coast Branch Office: 1314 Esperson Bldg., Houston 2, Tel. C-4-5918. *Representatives:* 1815 South Baltimore Ave., Kansas City 8, Mo., Tel. Victor 2618; 1101-05 Grant Street, Amarillo, Texas, Tel. 2-5262; 902 Central Bldg., Wichita 2, Kansas, Tel. 5-1965

BRADEN STEEL BUILDINGS

Launching winches built by Wilson Mfg. Co., Wichita Falls, Texas, using Diamond Roller Chain Drives and Diamond Flexible Couplings

The Drives of the Oil Industry *Launch Invasion Ships*



● In the largest shipbuilding program the world has ever seen—ship-launching winches designed and built in an oil field machinery manufacturer's plant are taking an active part.

These winches are used to launch large ships broadside in narrow bodies of water where usual launching methods would be impracticable. The drives, well-known to oil country men, are DIAMOND Roller Chains encased as shown in the illustration.

Long years of performance and proof of great strength, reliability, and positiveness made logical the selection of DIAMOND Chains to insure accurate control and safe lowering of the ship.

This is but another of many types of equipment used in war production where the uniform quality, great reserve strength and high power transmission efficiency of DIAMOND Roller Chains have made them first choice. DIAMOND CHAIN & MFG. CO., 441 Kentucky Avenue, Indianapolis 7, Indiana. Tulsa Office: 2238 Terwilleger Blvd.

DIAMOND ROLLER CHAINS

ATTENTION—OIL FIELD PRODUCTION MEN

To be sure of maximum life and to avoid delays and premature replacements—be extra sure that chains are lubricated at all times.

PUMPING UNITS

MOORE REDHEAD ... Chain Drive, Double Reduction, Pole Counterbalanced pumping units are available in five permanent sizes: 5 h.p. — 9 h.p. — 15 h.p. — 21 h.p. and 28 h.p. — a wide range of units designed to meet a broad range of lifting requirements.

LEE C. MOORE & COMPANY

INCORPORATED

PITTSBURGH • TULSA

EXPORT OFFICE • 30 ROCKEFELLER PLAZA, NEW YORK

What are you doing about engines in 1944

• This is an all-out war! It's being fought on two fronts—the battle line overseas—and the production line at home. Waukesha is right in there fighting—100 per cent—on both fronts.

• Oil is ammunition! That's your sector on the battle lines—and Waukesha's. And, unless we pull together, the battle won't be won.

• This means, briefly—that you and other oil field engine users must tell us *now* approximately *how many* Waukesha Oil Field Engines you'll need this year—and when you want them.

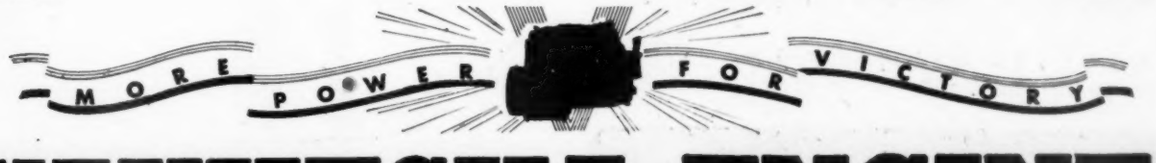
• **If you can't place an order—at least estimate your future needs.**

• On the basis of your orders and estimated needs for this year, Waukesha is now planning its future production schedules.

• Will you give us this vital-to-victory information *now?*

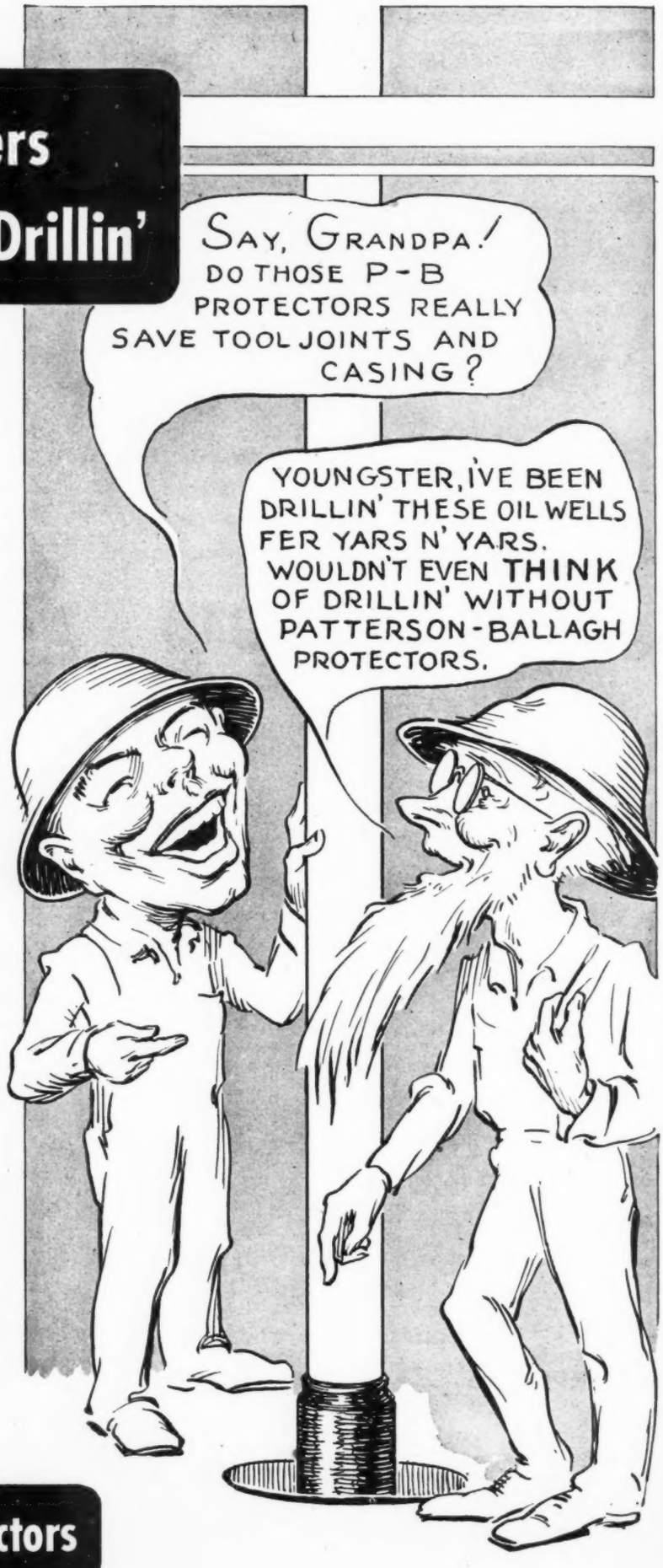
WAUKESHA MOTOR COMPANY, WAUKESHA, WIS.

NEW YORK • TULSA • LOS ANGELES



WAUKESHA ENGINES

Old Timers Know Their Drillin'


SAY, GRANDPA! DO THOSE P-B PROTECTORS REALLY SAVE TOOL JOINTS AND CASING?
YOUNGSTER, I'VE BEEN DRILLIN' THESE OIL WELLS FER YARS N' YARS. WOULDN'T EVEN THINK OF DRILLIN' WITHOUT PATTERSON-BALLAGH PROTECTORS.

By the use of Patterson-Ballagh Protectors and Stabilizers, oil well drilling has gone through a revolutionary stage. They have made possible deeper drilling and have permitted many economies in drilling. We understand that all wells being drilled below 10,000 feet (more than 1,000 to date) have used casing protectors, and almost all have been Patterson-Ballagh.

The rotary mud serves as a lubricant. Instead of tool joints and collars grinding against the casing, wearing both and endangering the well, these rubbers rotate on a film of mud. Thus, wear is practically nil on both drilling string and casing. The original diameter of tool joints is retained after months, and frequently years, of service.

The most recent improvement in the Patterson-Ballagh Protector is the heavy, rugged lip, top and bottom. Gripping power is gained, and, from reports, "ringing" of the drill pipe has been eliminated.

Heed the old timers and investigate Patterson-Ballagh's new lipped protector. Now made of PBX, the new oil proof synthetic.

SEE COMPOSITE CATALOG

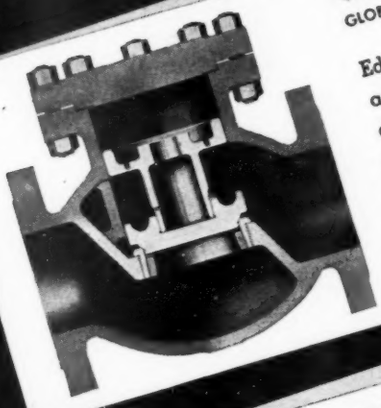
PATTERSON-BALLAGH
Los Angeles 1 • Houston 10 • New York City 6

Patterson-Ballagh Protectors

Edward CHECK VALVES

CAST STEEL LIFT CHECKS

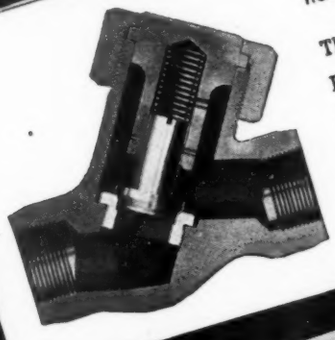
GLOBE AND ANGLE, 2½" to 14" 150 LB TO 2500 LB SP



Edward piston type check valves cut shock, slam and clatter to the barest minimum through exclusive design features that cushion disk action yet give fast, sure closure. Hour-glass disk-piston assembly moves in mirror smooth body-piston chamber, fully guided by three streamlined guide ribs integrally cast with body. Full area body gives maximum free dom of flow. Flanged or welding ends.

FORGED STEEL PISTON CHECKS

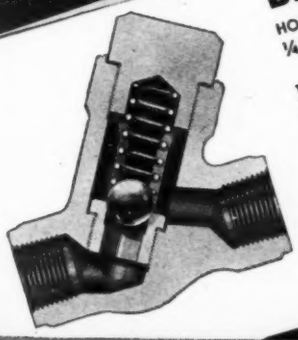
HORIZONTAL OR VERTICAL, ¼" TO 2" 150 LB TO 2500 LB SP



The same freedom from damaging shock that characterizes Edward cast steel check valves is a feature of Edward forged steel piston type check valves. Spring loaded in sizes under 1½ in. for tight, sure seating. Internal parts are designed for full flow area and cushioned closing action. Flanged or welding ends.

BALL CHECKS

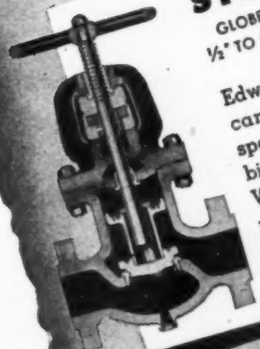
HORIZONTAL, VERTICAL & ANGLE ¼" TO 2" 150 LB TO 6000 LB



For viscous fluids or hydraulic service, Edward ball checks are ideal. The stainless steel ball, carefully mated to EValloy stainless steel seat is guided by two integral steel ribs. A spring aids seating.

STOP-CHECKS

GLOBE, ANGLE AND SEPARATED ½" TO 8" 150 LB TO 2500 LB SP



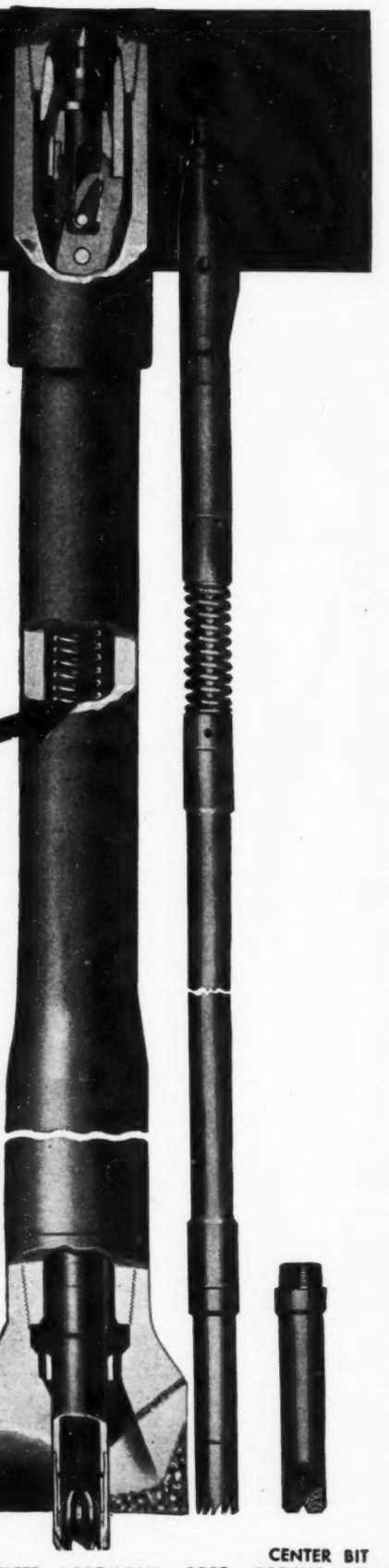
Edward stop-check valves can be used where cost or space limitations make combination valves desirable. Widely used for feedline service. Available with handwheel, gear or motor operation.

THE EDWARD VALVE & MFG. CO., INC.
East Chicago, Indiana

E V

EDWARD *Steel* VALVES

LOWER YOUR CORING COSTS WITH The REED 'BR' Wire Line DRILLING-CORING OUTFIT

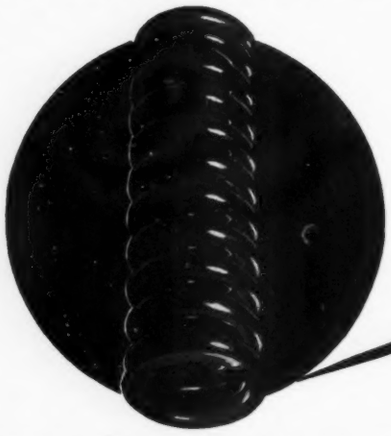


This Simple

PROTRUSION REGULATOR SPRING

assures recovery of

CLEAN, UNCONTAMINATED CORES



The REED "BR" Protrusion Regulator Spring is provided to regulate the load upon the core cutter head so that the proper weight is always applied upon the core cutter head.

The spring permits retraction of the cutter head into the drilling bit when the cutter head is first set on bottom, and allows the cutter head to core ahead of the drilling bit in soft formation to obtain a high percentage of uncontaminated core. This is a decided advantage when coring soft sands, shales and broken formations that may be broken up by the bit or washed away by slush action.

When coring in hard formations the spring permits retraction of the cutter head within the drilling bit and protects the core barrel assembly and cutter head from excessive weight. Retraction of the cutter head within the drilling bit also permits full drilling efficiency in the hard formations.

"BR" HARD FORMATION DRILLING BIT

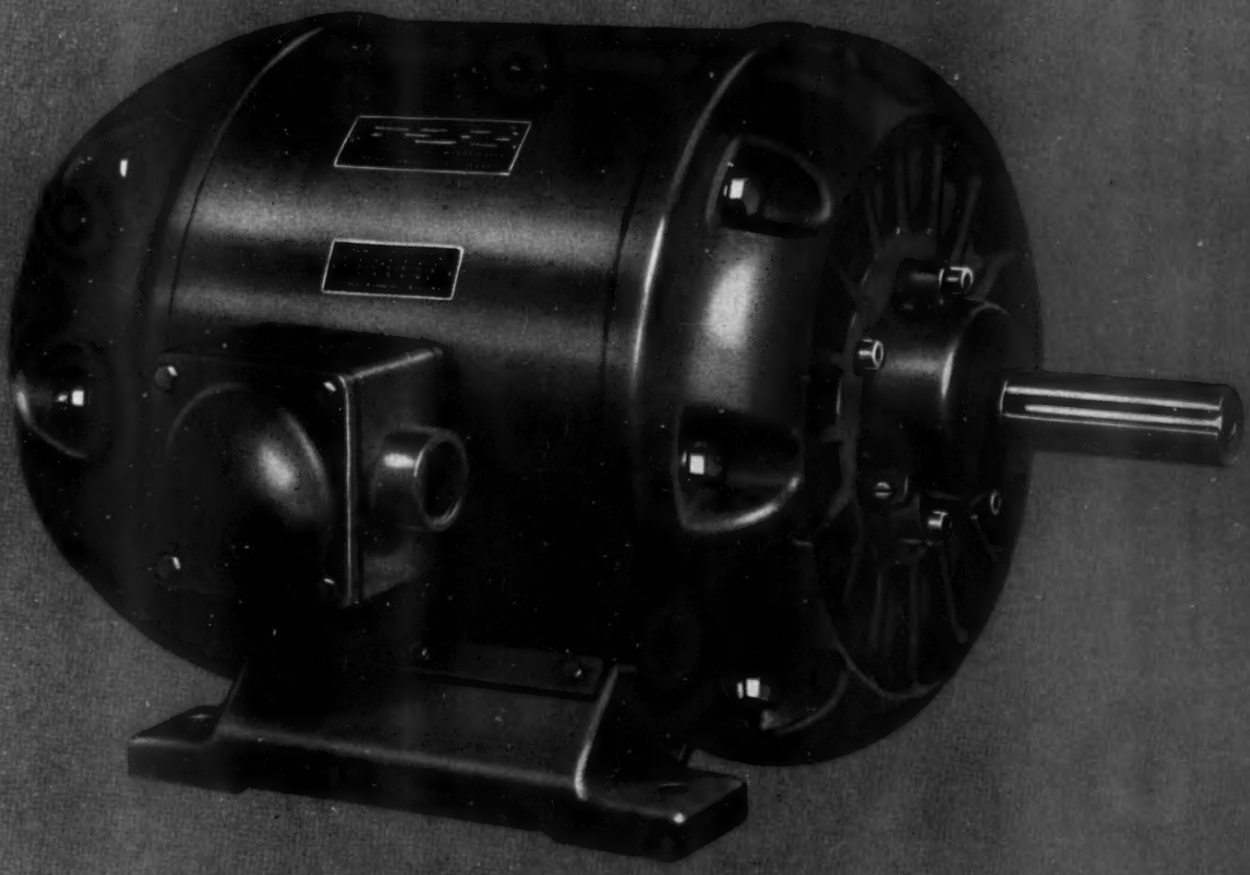
COMPLETE ASSEMBLY WITH SOFT FORMATION DRILLING BIT

CORE BARREL

CENTER BIT FOR USE WHEN DRILLING ONLY

REED ROLLER BIT COMPANY

P. O. BOX 2119 HOUSTON 1, TEXAS EXPORT OFFICE 1836 R. C. A. BLDG., NEW YORK, N. Y.



There is a size and type **LOUIS ALLIS** *electric motor for every industrial requirement.*

THE LOUIS ALLIS CO., MILWAUKEE 7, WIS.

Your Electric Motor Requirements

The day of trying to use a standard motor for a special job is about over.

Machinery designers, and production managers have learned that it is much more efficient and economical to obtain a motor with exactly the electrical and mechanical characteristics required to perform a specific job than it is to try to doctor up a standard "shelf" motor to do the job.

Speed and horsepower are no longer the major measuring stick of motor requirements—they are merely incidental to the many other characteristics available in electric motors today.

For over forty years we have been developing special motors for special jobs—our engineering department has a wealth of experience along this line—

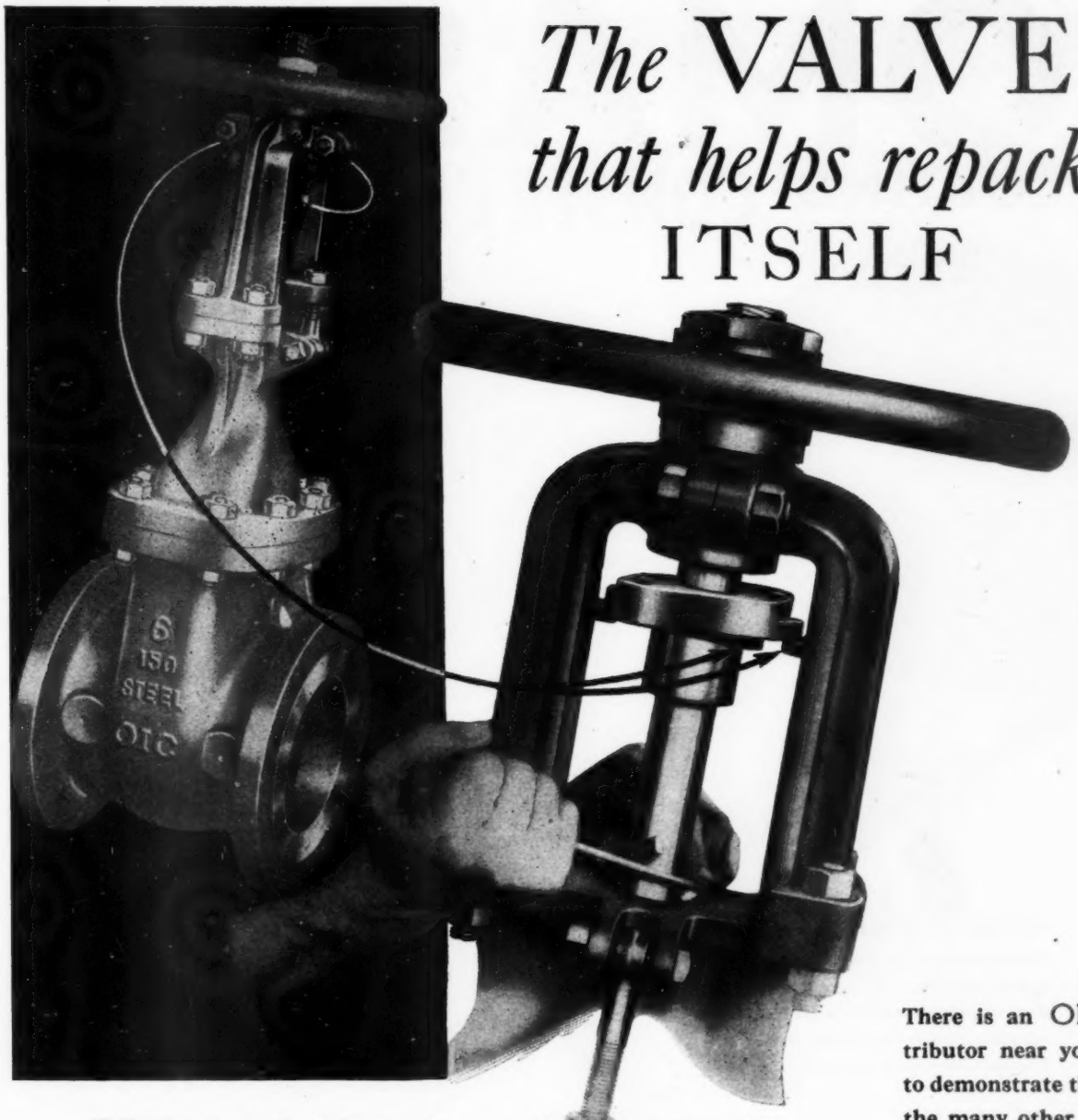
* * *

Our engineering development department has created many outstanding — perhaps revolutionary — improvements in electric motor design, construction and performance that are now playing an important role in helping win this war.

Many of these important new motor developments will also play an important role in the post-war period.

Our engineering development department will welcome the opportunity of discussing your post-war electric motor problems with you.

THE LOUIS ALLIS CO., MILWAUKEE 7, WIS.



The VALVE *that helps repack* ITSELF

HERE'S the Steel Valve that actually helps to repack itself under pressure, enabling you to do a faster, better job.

The gland and follower are held together by self-locking lugs and are raised as one unit for repacking. The grooved ears on the gland fit into tongued shelves on the yoke when in the raised position.

Eye-bolts hold the entire unit down firmly on the packing. In the repacking process they swing down out of the way — never to be lost or misplaced.

These are just a few of the exclusive features and time and money saving advantages of OIC Steel Valves.

There is an OIC Distributor near you ready to demonstrate these and the many other features of OIC Steel Valves to you. Call him, or write to us for complete details.

ARMY E NAVY

OIC

THE OHIO INJECTOR COMPANY

WADSWORTH, OHIO

Quality Leaders in Valve Manufacture Since 1883

SOMASTIC

PIPE COATING CONSERVES PIPE STEEL

PRE-WAR PRACTICE...

Formerly steel pipe was used in weights 25% to 50% greater than required to contain line operating pressures as an allowance for corrosion losses.

TODAY...

War-scarce steel is conserved by using only the minimum weight of steel pipe necessary for operating pressures, with SOMASTIC Pipe Coating to assure corrosion prevention.

Permanent Pipe Protection

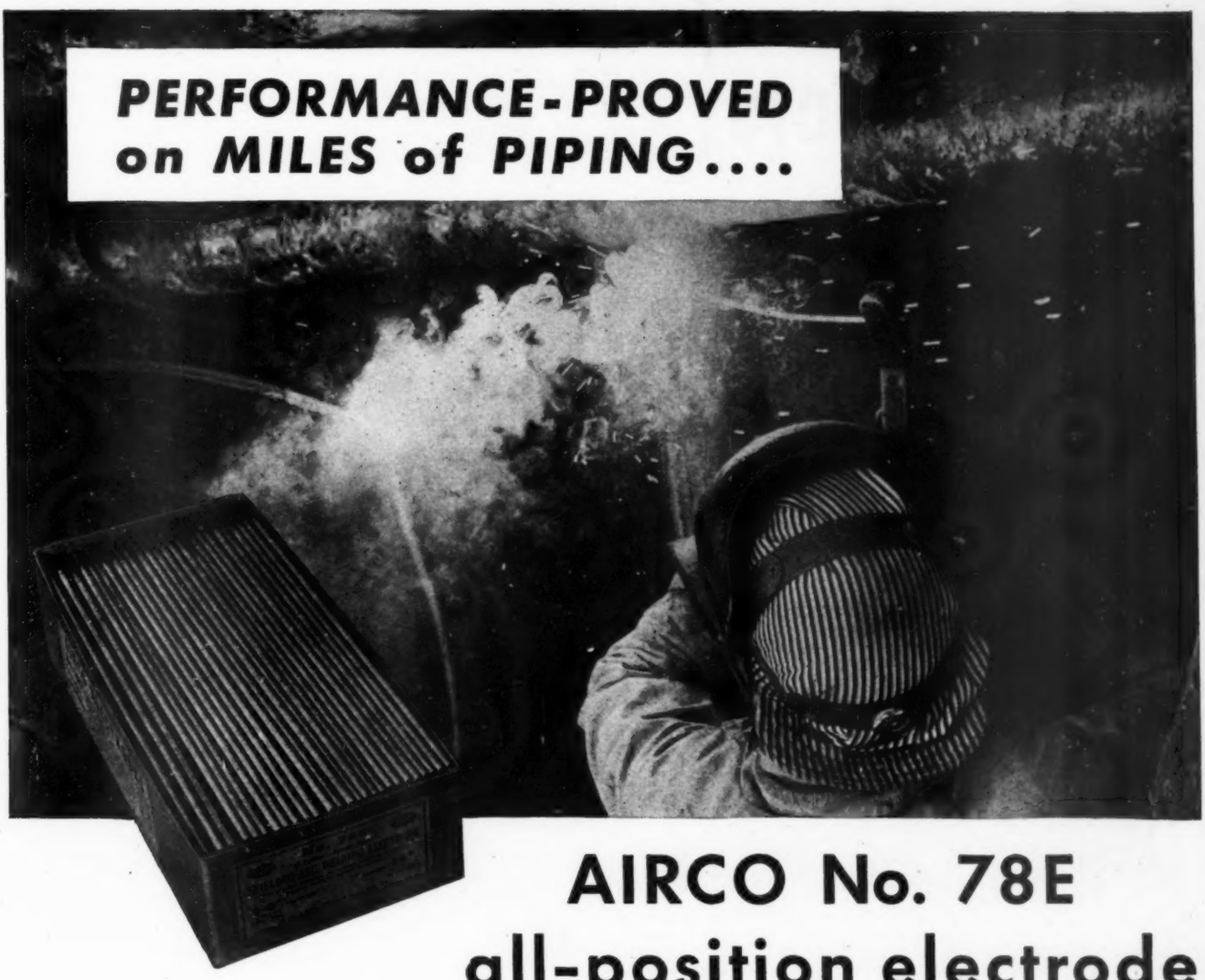
PORTABLE PLANTS AVAILABLE EVERYWHERE

The permanence of SOMASTIC protection makes the reduction of steel wall thickness safe engineering practice and sound economic procedure.

SOMASTIC
REG. U. S. PAT. OFF.
PIPE COATING

INDUSTRIAL ENGINEERING CO.

WILMINGTON, CALIFORNIA, Box 457 HOUSTON, TEXAS, Box 2091 BARTLESVILLE, OKLAHOMA, Box 149



AIRCO No. 78E all-position electrode

Wherever strong, leakproof welds are needed, you'll find Airco No. 78E electrode in use. This all-position shielded arc electrode has proved its superiority on numerous pipeline installations.

Because of its spray-type arc action and quickly-solidifying deposits, Airco No. 78E provides faster and better welding in the vertical and overhead positions.

This electrode is used with D.C., reverse polarity (electrode positive). All diameters can be used for flat (horizontal position) welding – multiple pass, lap, butt, or fillet. For vertical and overhead welding 1/8", 5/32" and 3/16" diameters are used.

Airco No. 78E conforms to A.W.S. and A.S.T.M. specifications for Classification E-6010. It meets requirements of A.S.M.E. Boiler Code for Fired and Unfired Pressure Vessels and conforms to A.P.I. requirements. For full details on this and other Airco electrodes, call or write your nearest Air Reduction office.

★ BUY UNITED STATES WAR BONDS ★

AIRCO WILSON

AIR REDUCTION

General Offices: 60 EAST 42nd STREET, NEW YORK 17, N. Y.

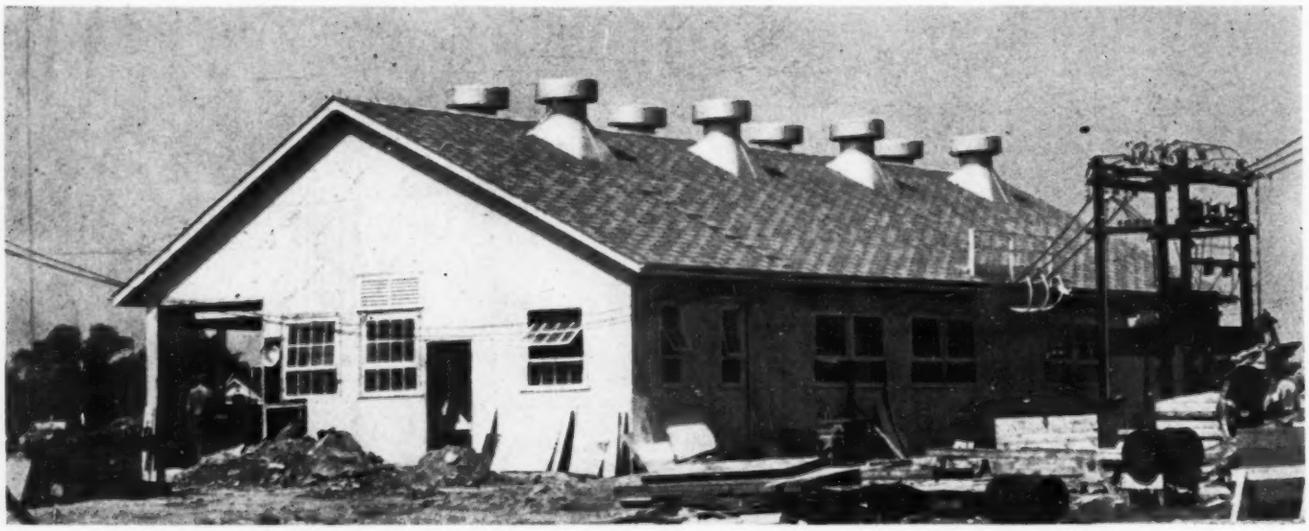
In Texas: MAGNOLIA AIRCO GAS PRODUCTS CO. • General Offices: HOUSTON 1, TEXAS

Offices in all Principal Cities

Carey PRODUCTS

ASBESTOS-CEMENT SHINGLES
ASBESTOS-CEMENT SHEATHING
ASBESTOS-CEMENT INSULATED SHEATHING
SATURATED ROOFING FELT
ASPHALT ELASTITE EXPANSION JOINT

Help Assure PEAK EFFICIENCY of PUMP HOUSES...



"Big Inch" War Emergency Pipeline Pump House. Carey Products were used here, as on a large number of other Pump Houses on this vital "oil artery" linking Texas fields with the east coast.

...on "BIG INCH" PIPELINE!

A large number of Pump Houses are required to keep war-vital oil flowing at top speed through the famous "Big Inch" War Emergency Pipeline.

For many of these Pump Houses, large quantities of CAREY Products have been used, including *Asbestos-Cement Shingles and Sheathing; Asbestos-Cement Insulated Sheathing, Saturated Roofing Felt and Asphalt "Elastite" Expansion Joint.*

In addition, vast amounts of CAREY *Asbestos Pipeline Felt,* mechanically wrapped on the Pipeline itself, protect "Big Inch" from corrosion.

Selection of CAREY Products for this huge project is strong evidence of the recognized quality of these dependable materials, the large capacity of CAREY production facilities, and the efficiency of CAREY service.

If the job is big . . . if it must be completed on time . . . you can always depend on CAREY. For details on any of the Products listed above —or on super-efficient Carey 85% Magnesia or "Hi-Temp" Heat Insulations—write Dept. 88.

★ **THE PHILIP CAREY MFG. COMPANY** ★

Dependable Products Since 1873

LOCKLAND, CINCINNATI, OHIO

In Canada: The Philip Carey Co., Ltd.

Office and Factory: Lennoxville, P. Q.

CHAPMAN OUT-LIVES THEM ALL

One reason this small gate valve gives longer service is the way Chapman builds extra life into its seats and plugs. They're toughened to take longer service.

And for service that's extra severe, Chapman will *superharden* these parts by an exclusive process which imparts even longer wearing qualities. When these parts finally do wear out, Chapman is ready to help you make quick, easy replacements.

Other Chapman advantages: Quick-acting threads give you faster openings and closings—remove the threat of sticking or freezing. And you can repack under full pressure as the pressure is not transmitted to the stem.

Chapman List 960 is available in sizes from ¼" to 2" for all pressures up to 800 lb. at 750° F. or up to 1500 lb. cold working pressure . . . with inside or outside rising stem.

CHAPMAN LIST 960 stays on your lines l-o-n-g-e-r!

THE **CHAPMAN VALVE** MFG. CO.
INDIAN ORCHARD, MASS.

WORLD EXPERIENCE FOR YOUR FUTURE PIPE LINES

Like blood vessels in the human body, pipe lines are essential to our national economy; vital to our allied victory. We have accepted with deep appreciation, and executed with speed the great responsibilities which have been assigned to us in a world at war.

The past two years have found the Williams Brothers organization engaged in far-flung operations in a war-torn world. Our entire construction effort has been devoted to building important new pipe lines; enlarging existing facilities in the United States, and the execution of important contracts in other countries for quicker, greater distribution of oil and petroleum products to the strategic points at home and abroad.

Just where our forces of engineers, skilled workmen and modern equipment are and have been at work in recent months is a military secret. Your own future pipe line requirements any place in the world may be discussed, planned and projected by Williams Brothers with equal secrecy.

WILLIAMS BROS. CORP.

GENERAL CONTRACTORS ENGINEERS

Oil • Gas • Gasoline • Water

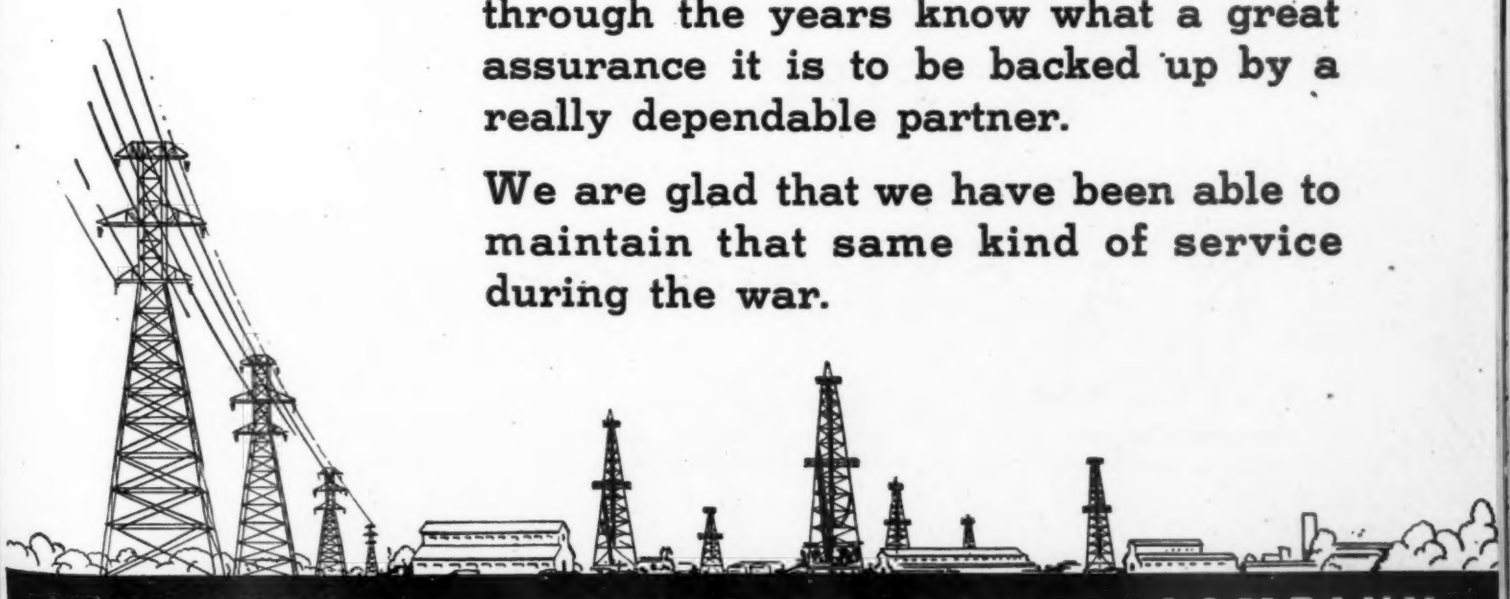
Pipe Lines and Pump Stations

NEW YORK • TULSA • ATLANTA • HOUSTON

DEPENDABLE ELECTRIC POWER

You oil men who have used our service through the years know what a great assurance it is to be backed up by a really dependable partner.

We are glad that we have been able to maintain that same kind of service during the war.



HOUSTON LIGHTING AND POWER COMPANY

WRINKLE-BENDING AN 18" NATURAL GAS LINE

Builders of: Section 2, 24" Natural Gas Line From the Navidad River to Splendora, Texas, A Distance of Approximately 120 Miles

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PIPE LINE

Engineers and Contractors

N. A. SAIGH COMPANY

P. O. Box 832

Beaumont, Texas

MEMBER

Associated General Contractors

Associated Member ASCE

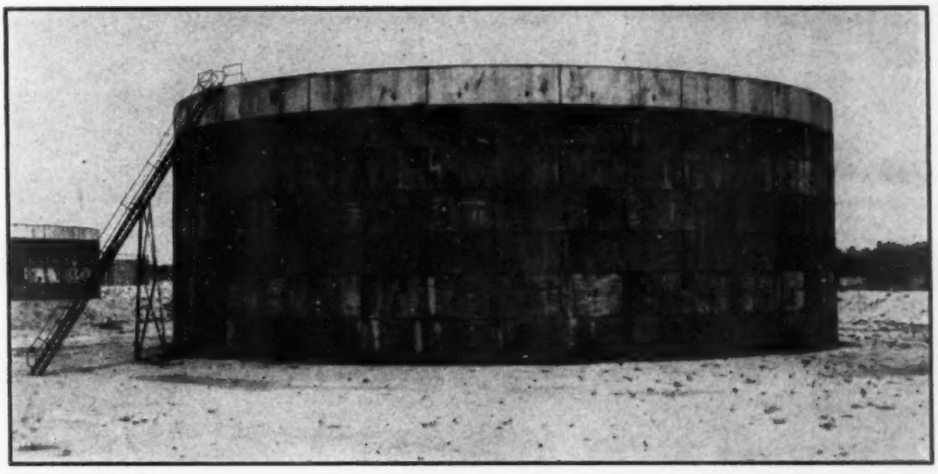
Professional Engineer

HOME OFFICE

510-512 Builders Exchange Bldg.

San Antonio, Texas

Safe Storage



"on the BIG INCH"

Safe storage is always important. We are proud to be identified as the "Erectors of Steel Storage on the Big-Inch Line."

We offer modern facilities for the construction of steel storage.

★

STEEL TANK CONSTRUCTION COMPANY

DALLAS, TEXAS *and* HOUSTON, TEXAS

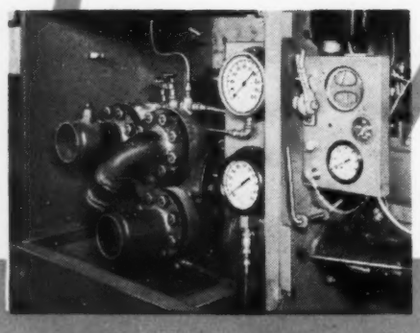
Here are pumps that really have "gone to war"—Byron Jackson Pick Up Pumps, commonly known as the P.U.P. Hundreds of PUP's saw service in North Africa pumping vital gasoline from base storage through portable pipe lines up to the combat lines.

Skid-mounted for ease in transporting and unloading—highly efficient in operation—trouble-free and long wearing—these are fundamentally the same Byron Jackson PUP Pumps which have seen service for years in various branches of the petroleum industry, performing dozens of related services.

We solicit your inquiries for Byron Jackson Pumps for service in the war effort, and will endeavor to supply your needs.

BYRON JACKSON CO.

Houston • LOS ANGELES • New York



McGREGOR & REED
Tulsa, Oklahoma
Prime Contractors

ARMY E NAVY

Since 1872

BYRON JACKSON PUMPS

CENTRIFUGAL PUMPS FOR *Every* SERVICE

Pumping unit . . . dependably powered with LEROI valve-in-head engine

TURN THE PAGE

Le Roi Engine Features

OVERHEAD VALVE ARRANGEMENT

provides greater accessibility for adjustments and reduces maintenance and repairs to a minimum. You are assured of fuel economy and lower overall operating cost.

REMOVABLE WET SLEEVE CYLINDERS

are easily and inexpensively replaced. Eliminate reboring, and assure uniform expansion of true cylinder bores. Reduce wear, permit accurate control of cylinder lubrication, eliminate oil pumping.

HIGH PRODUCTION STANDARDS

Exceptional precision in machining, backed up by many precision instruments such as dynamic balancers for obtaining maximum perfection of balance in crankshafts.

WEATHERPROOF, PILFERPROOF ENCLOSURES

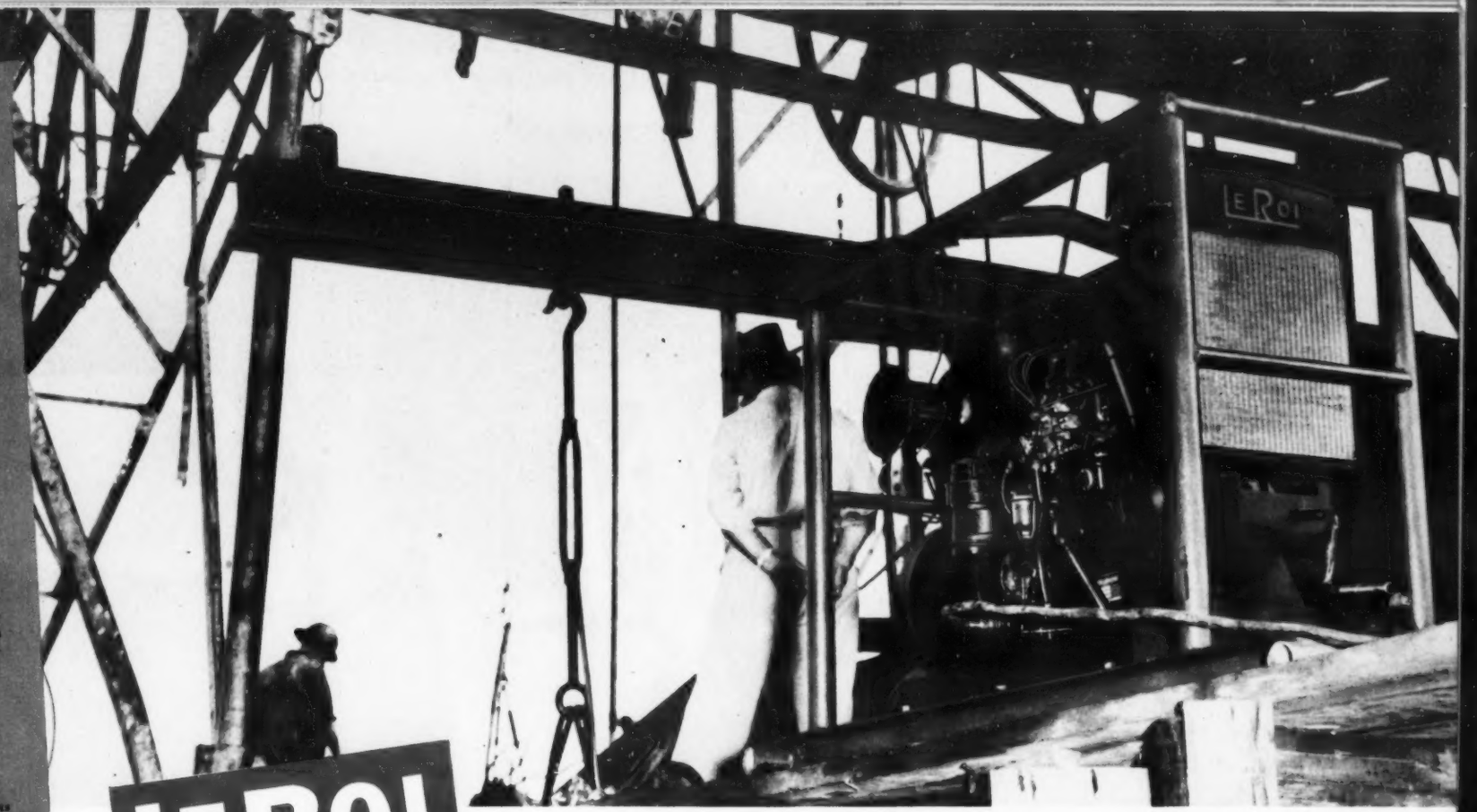
Self-contained power units housed for protection against the elements. They're pilferproof for they can be locked to prevent tampering with or theft of accessories.

HARDENED VALVE SEAT INSERTS

minimize the frequency of valve adjustments, reduce grinding to a minimum. Also considerably reduce wear on valve seats, pitting of the valves, and danger of valve burning.

CAREFULLY INSPECTED

The results of thorough inspection and testing show up for years in steady, dependable service with fewer stoppages and less lost time.



LE ROI Engine-Generator Units Cost Less... Only $110 per Kw. Hour* in the 5 Kw. Size

ON THE REVERSE SIDE — A well-known pumping rig—LE ROI-POWERED—to stand up dependably under the grind of continuous oilfield service. Le Roi engines can "take it" without trouble or shutdowns.

Extra kilowatt hours per dollar mean greater savings — more profits for you. These units have been specially designed for portability, compactness, simplicity, and economy consistent with dependable performance. They are conservatively rated and have high intermittent overload capacity — but are protected against heavy, continuous overloads by an automatic circuit-breaker.

For operating lights, universal appliances and tools, D.C. radios, and small D.C. motors, you can depend on Le Roi engine-generator units to give you more capacity for your money.

Write your nearest Le Roi distributor concerning the adaptability of a Le Roi engine-generator unit to your particular requirement.

* Approximate price f.o.b. Milwaukee.

LE ROI COMPANY
1766 S. 68th St., Milwaukee 14, Wis.
BRANCH: TULSA, OKLAHOMA

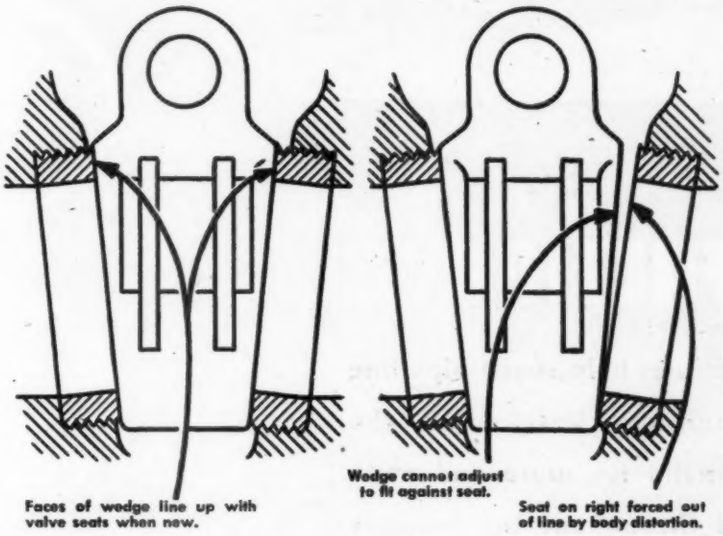
LE ROI

Distributors

Western Machinery Co.—St. Louis, Mo.; Centralia, Ill.; General Machine & Supply Co.—Wichita Falls, Odessa, Tex.; Southern Engine & Pump Co.—Houston, Dallas, Kilgore, Tex.; Le Roi Rix Machinery Co.—Los Angeles, Calif.

CENTRIFUGAL PUMPS FOR Every SERVICE

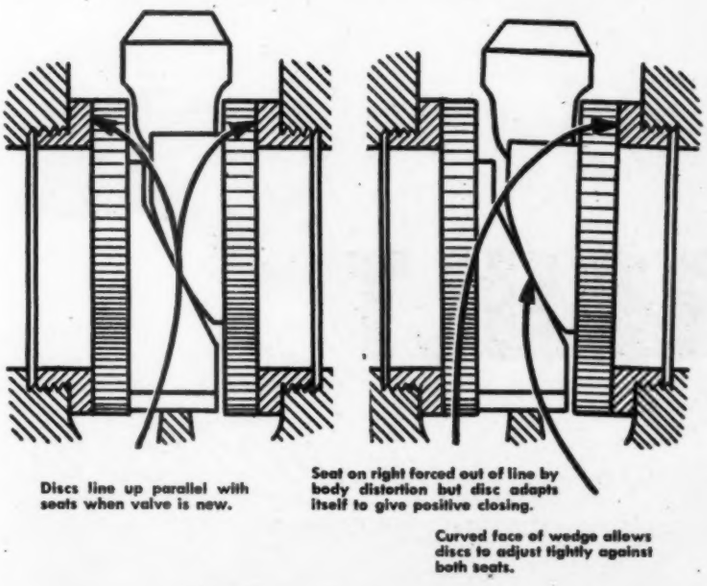
"Body Blows" THAT KNOCK OUT VALVES


Faces of wedge line up with valve seats when new.
Wedge cannot adjust to fit against seat.
Seat on right forced out of line by body distortion.

ABOVE—What happens before and after a taper seat gate valve is subjected to body distortion is shown in these somewhat exaggerated diagrams.

BEFORE AND AFTER

BELOW—How the Darling Fully Revolving Double Disc Parallel Seat gate valve continues to give positive closing despite body distortion.


Discs line up parallel with seats when valve is new.
Seat on right forced out of line by body distortion but disc adapts itself to give positive closing.
Curved face of wedge allows discs to adjust tightly against both seats.

ANY valve is tight on the drawing board, or on the assembly floor, but frequently a valve is installed with a pipe out of line, so that the valve body is subjected to unexpected "line strains."

Or expansion bends are not properly installed, so that the valve has to take the punishment of expanding and contracting lines.

The distortion of valve bodies is a continuous and almost microscopic process, but is one of the chief causes of leaking valves. Under the body blows of high temperature and pressure the valve bodies will change shape and valve seats will move out of their original line-up, preventing tight closing.

Over forty years ago Darling Valve & Manufacturing Company designed a valve that could take these body blows and still give positive closure. In the Darling Fully Revolving Double Disc Parallel Seat valve, there are two important features:

1. The floating discs are free to adapt themselves to change in the shape of the valve body, and to changed position of the valve seats.
2. The discs are fully revolving, seating in a different position each time, thus wearing evenly and always presenting a uniform surface against the valve seat. Even when worn thin the discs still furnish a positive seal.

Darling is the only valve which has this simple and efficient design. For "positive closing, year after year," thousands of experienced valve buyers specify Darling for all their tough jobs.

TRADE DARLING MARK

VALVE & MANUFACTURING CO.

WILLIAMSPORT, PA.

Perrault Brothers line traveling pipe coating and wrapping machine applying Philip Carey felt to 24" War Emergency Pipe Line. Perrault line traveling machines are made to wrap and coat 4" to 28" pipe.

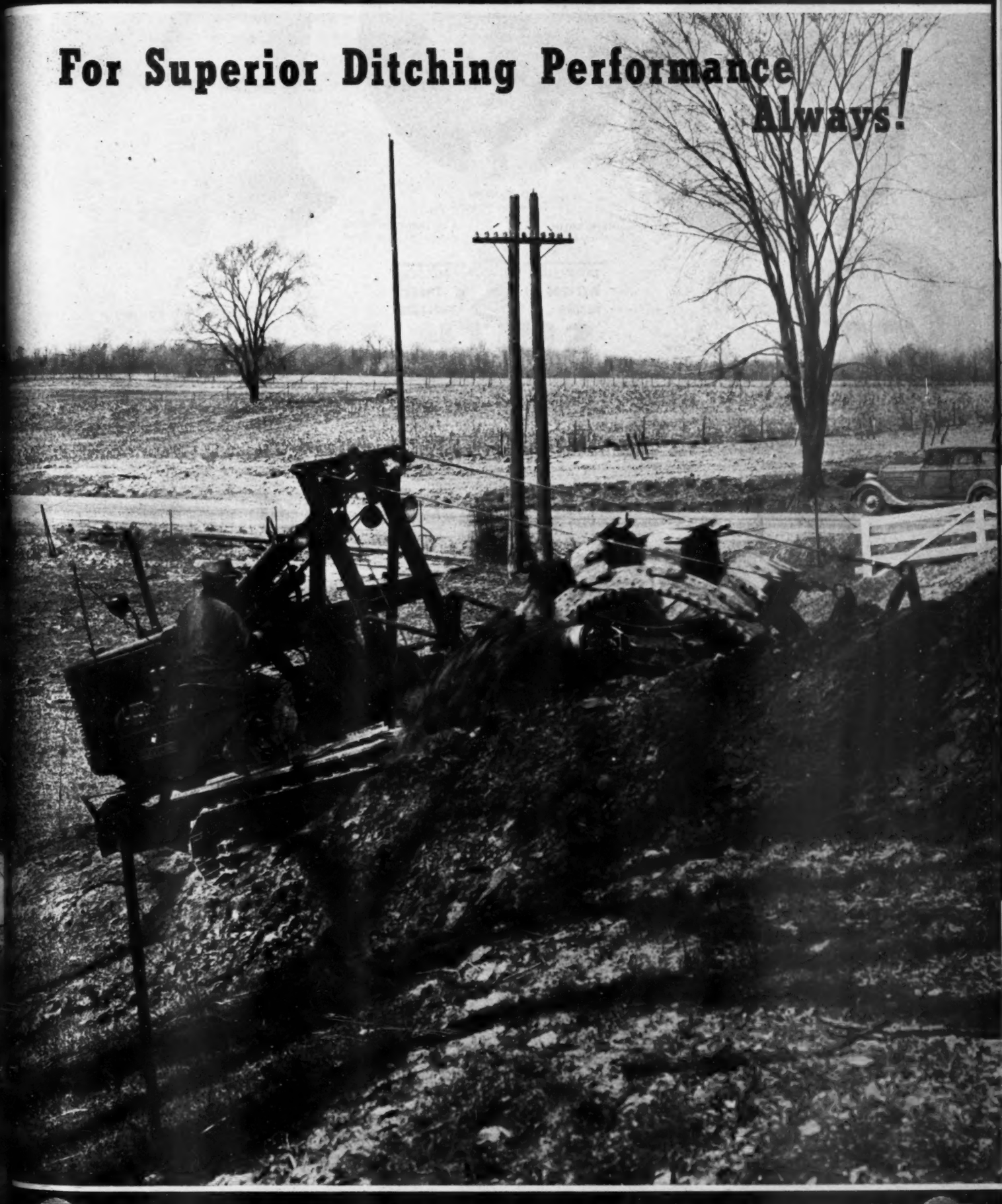
CERTAIN SATISFACTION...

PERRAULT BROTHERS—PIPE COATING AND WRAPPING MACHINES—PIPE LINE SUPPLIES
1130 NORTH BOSTON • TULSA 6, OKLAHOMA • TELEPHONE 5-1104

Brothers

Perrault Brothers yard coating and wrapping machine operation on 18" pipe with Philip Carey felt for Warren Petroleum Corporation. This machine will handle 3/4" to 28" pipe.

"CLEVELANDS"



THE CLEVELAND TRENCHER COMPANY

20100 ST. CLAIR AVE. *"Pioneer of the Small Trencher"* CLEVELAND, OHIO

"CLEVELANDS" Save More . . . Because they Do More

O. R. SMITH
Owner and Operator

J. H. (HERB) SMITH
Job Superintendent

F. A. (ARNOLD) SMITH
Manager of Construction

COMPRESSORS
DITCHERS
DOZERS
WELDERS
TRUCKS
TRACTORS

SMITH

CONTRACTING CO.

PIPE LINE CONSTRUCTION

ODESSA, TEXAS

MAURICE J. ROGERS
Chief Accountant and Purchasing Agent

The organization with Pipe Line "Know How"

M. M. (MARVIN) DONAHO
General Office Manager

C. C. (CHARLIE) CRAIG
Chief Operator of Heavy Equipment

F. C. (FRANK) CRAIG
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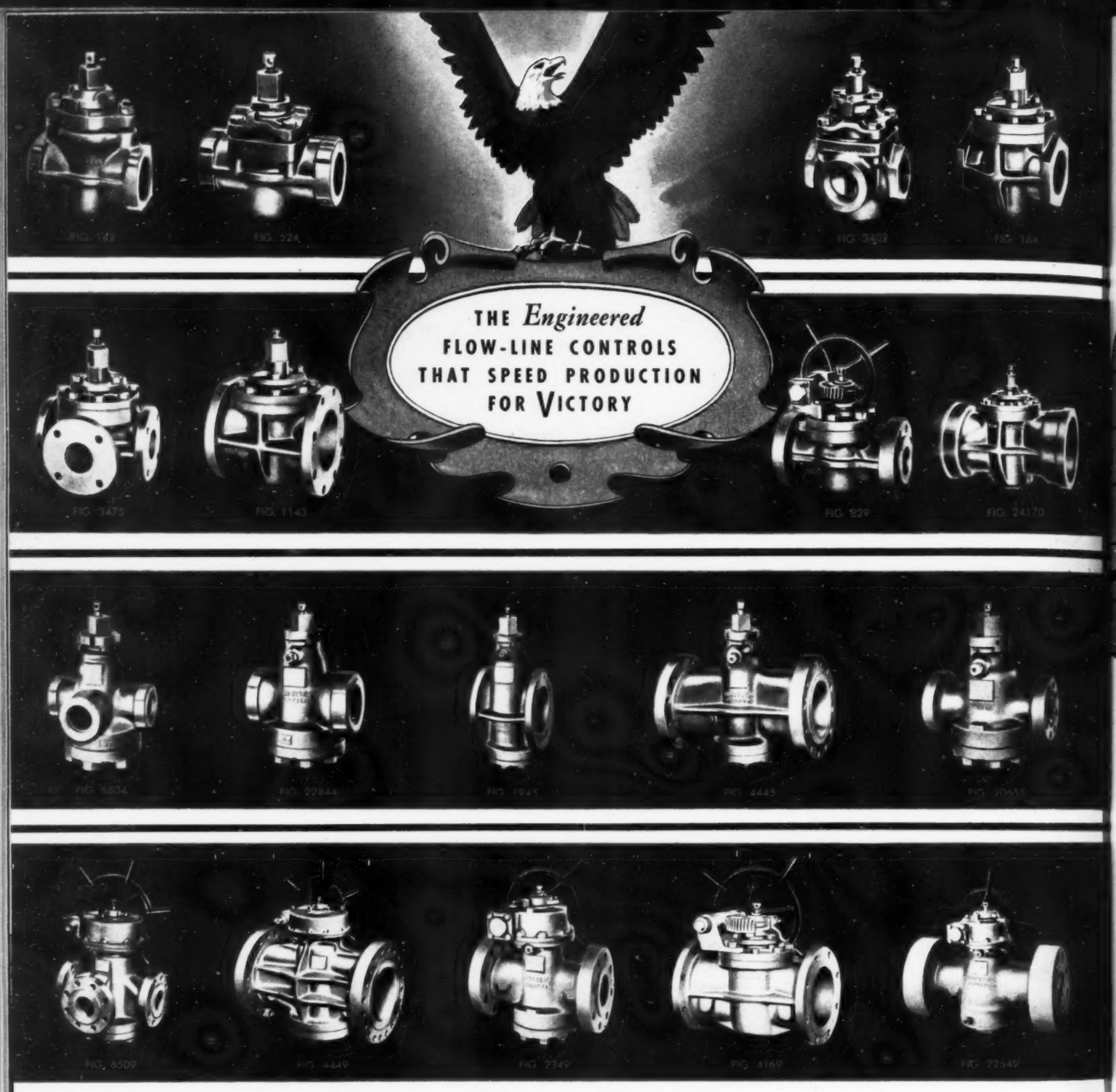

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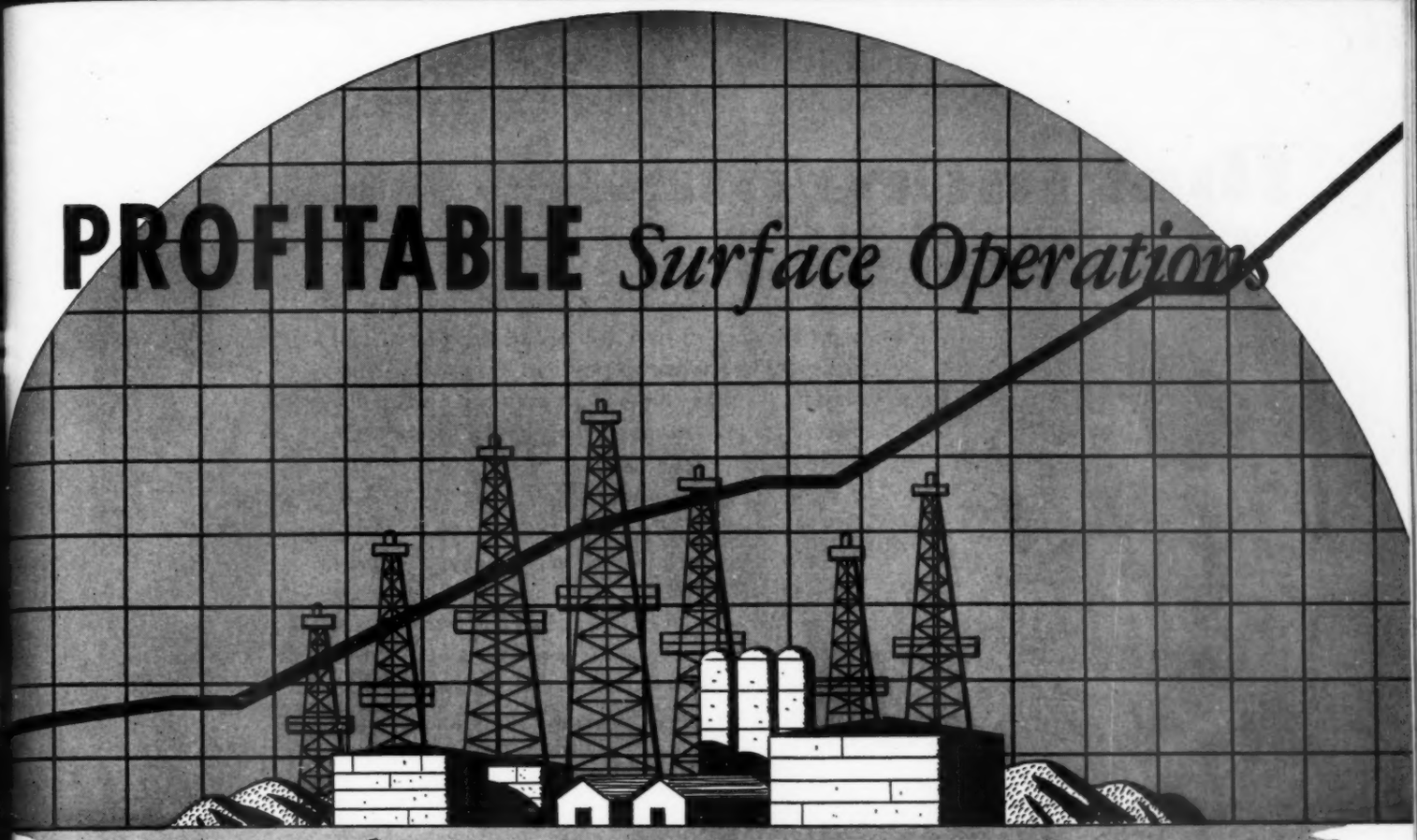

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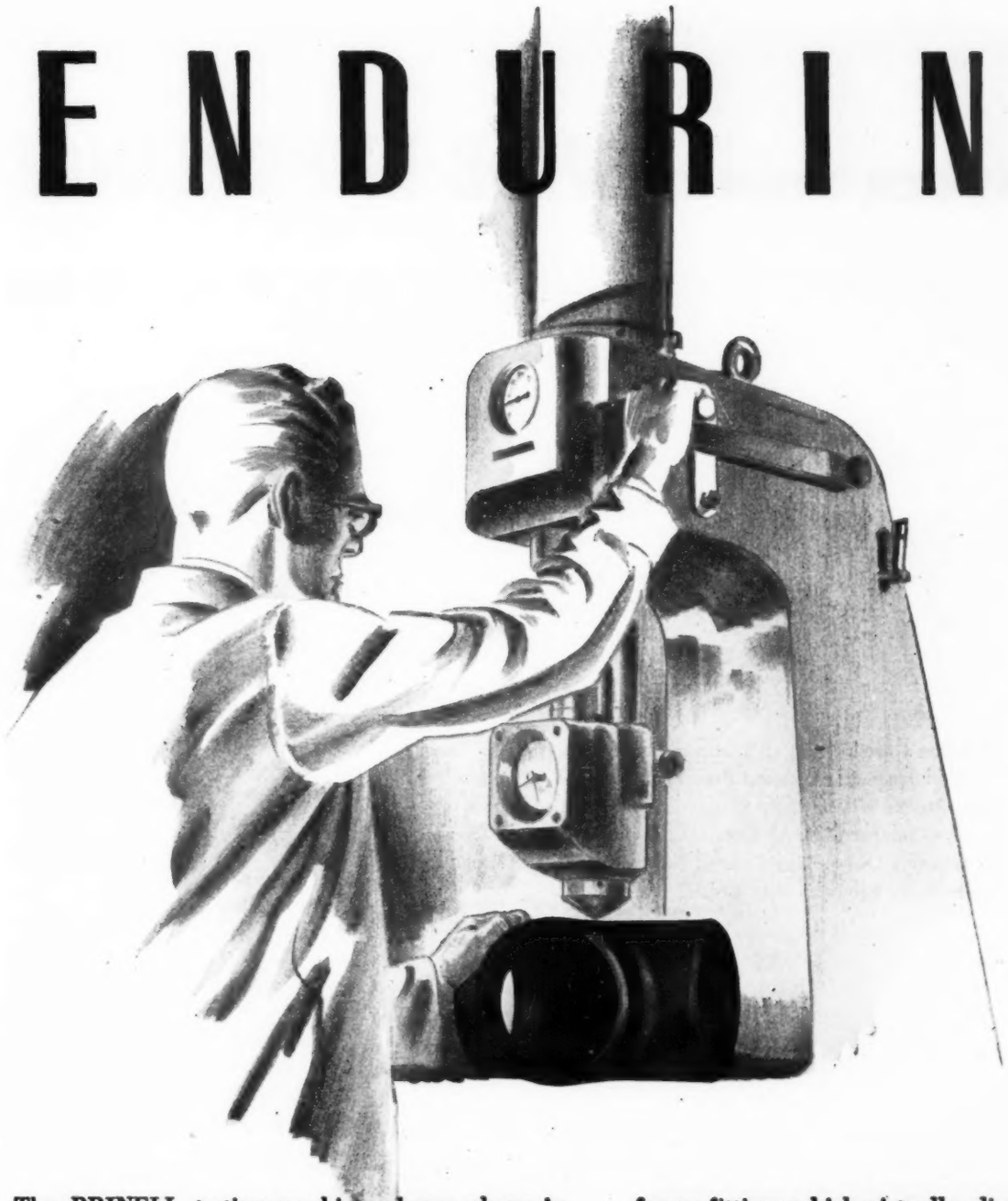

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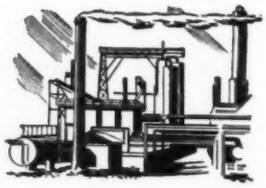

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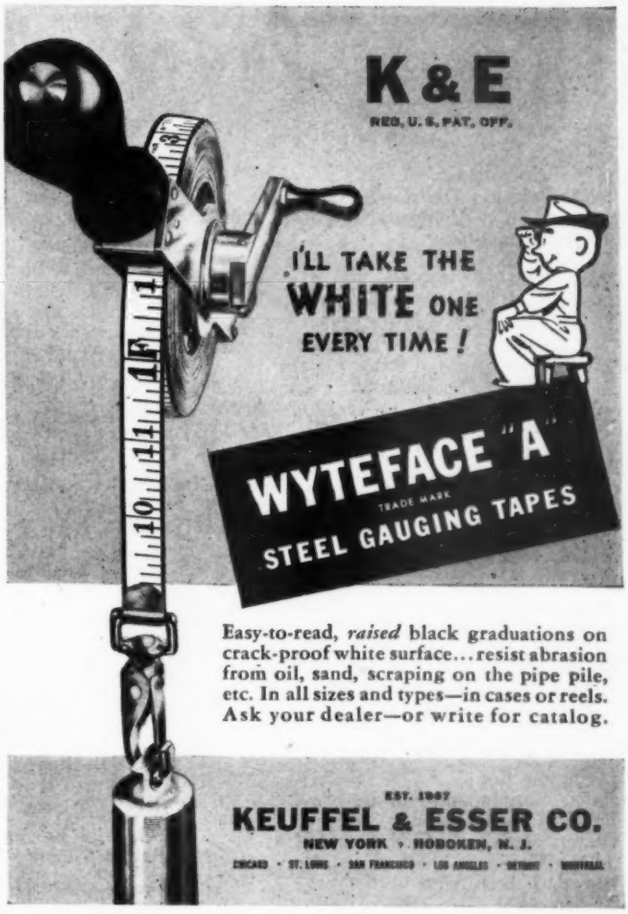

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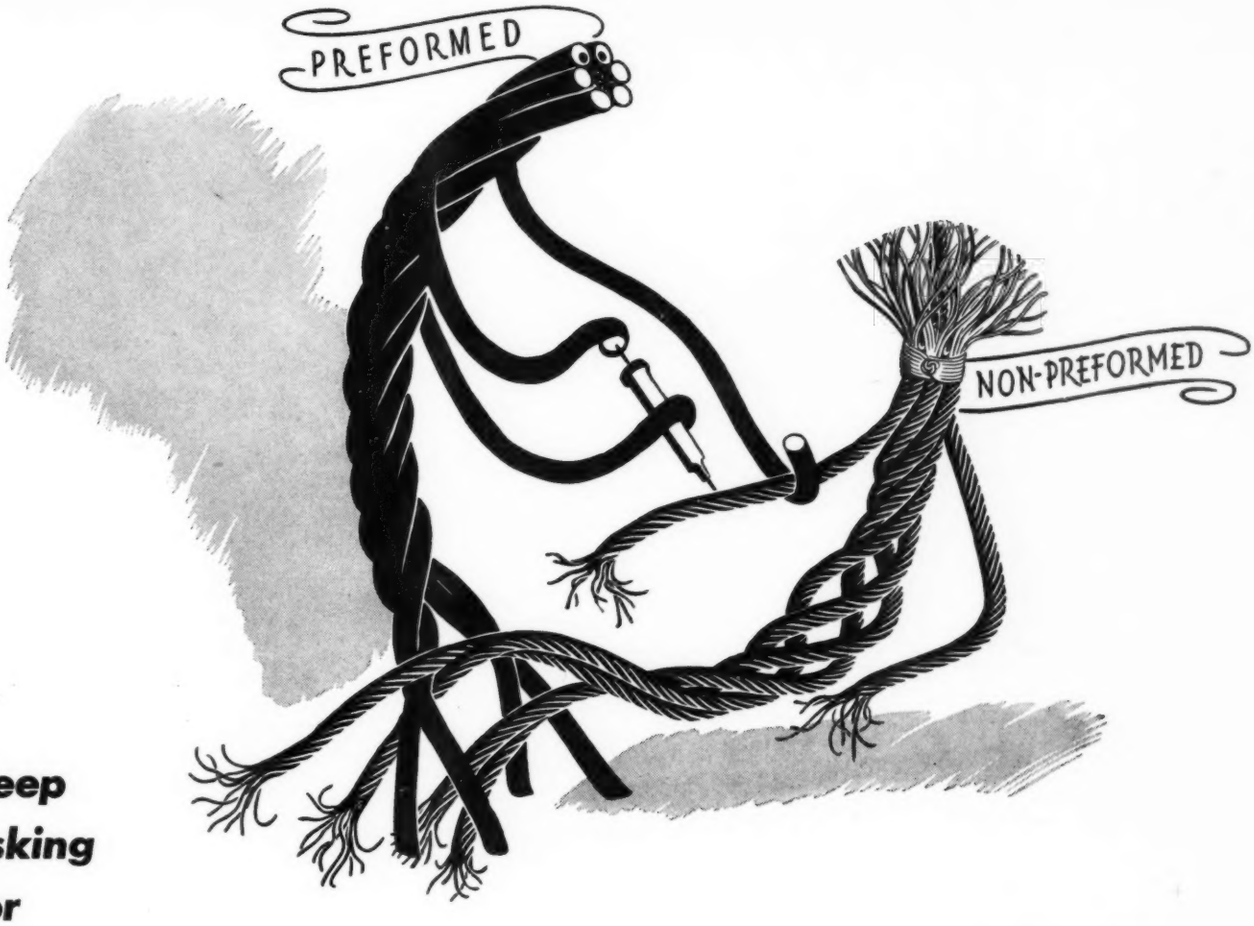

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